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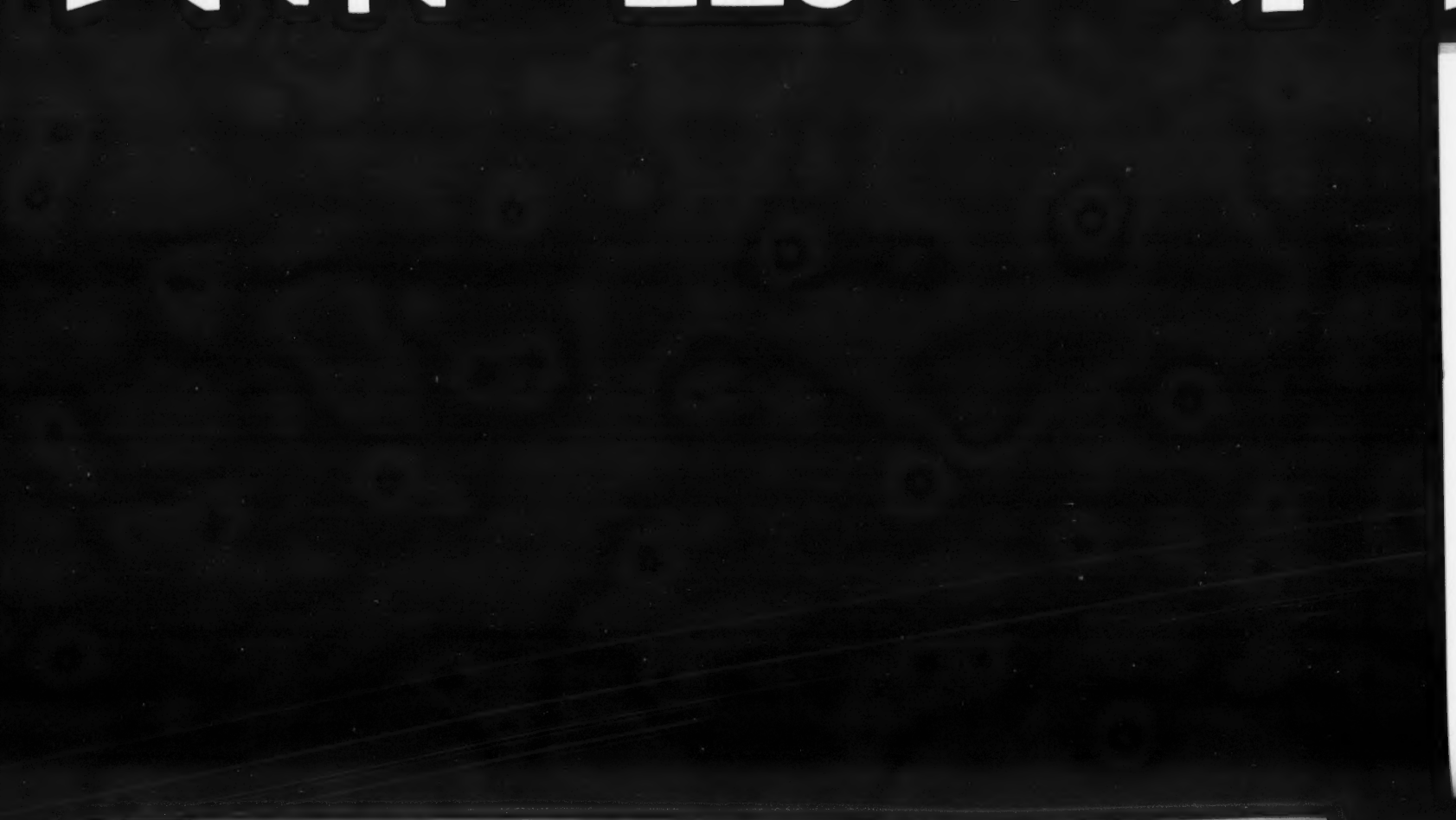

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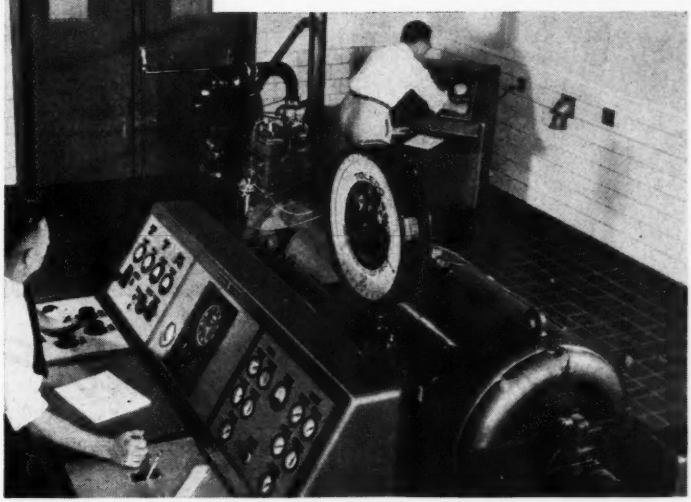

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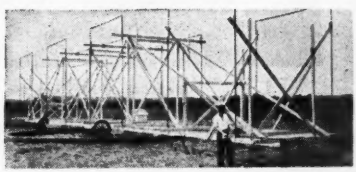

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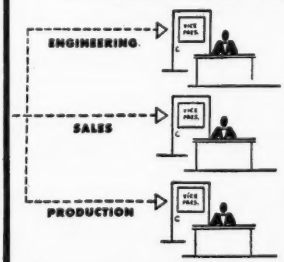

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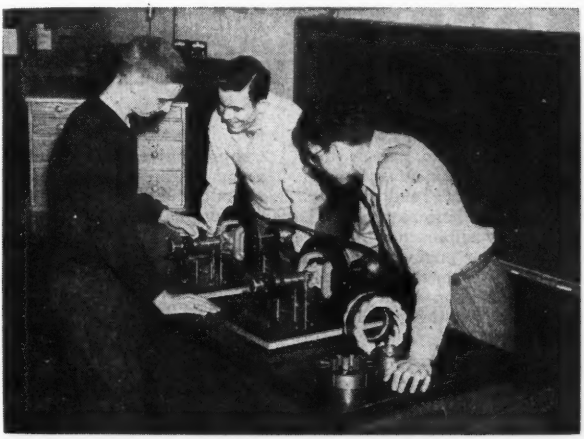

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Do You Know—

► A grant of $30,000 to the ASEE has been authorized by the Carnegie Corporation of New York for a comprehensive investigation of the Humanistic-Social Studies in the engineering curriculum. The Humanistic-Social Division of ASEE, under the Chairmanship of Professor Sterling Olmsted, prepared the proposal which contemplates a two-year comprehensive investigation of the subject matter organization and teaching methods in the social sciences and humanities courses for engineers. This project will appraise the present status of these programs and identify those programs which appear to be well-conceived and have considerable merit. It will prepare recommendations for improvement of this area of instruction. The project will be directed by Professor George A. Gullette, Head of the Department of Social Studies, North Carolina State College. He will be assisted by an Advisory Committee consisting of a number of leading authorities in the field. The project will be launched just ten years after the Hammond Report, which advocated careful attention to this area of instruction.

► Plans for the two Summer Institutes to be held in the Summer of 1954 are progressing satisfactorily. One of these will deal with the influence of solid state physics upon engineering and engineering education, the other will deal with nuclear science in engineering. These conferences will endeavor to obtain an orderly and systematic organization of the fundamental concepts in these fields for teaching purposes. Each conference will consist of a closed meeting of a number of leading research scientists and engineers to conduct a preliminary exploration of the subject matter. This will be followed by conferences open to a limited number of ASEE members in the Summer of 1954. The Solid State Physics Closed Conference will be held at the University of Illinois and the open conference at Carnegie Institute. The Nuclear Science Closed Conference will be held at Columbia University and the open conference at Northwestern University.

► The YET movement in the Society has gained great momentum as a consequence of steps taken by the Divisions and Sections of the Society to bring young teachers into active participation. This can be a highly significant development which will greatly enrich the professional competence and broaden the outlook of young teachers. A number of colleges have established YET committees among their faculty members. They attest to the vigor and enthusiasm which young teachers have displayed in this movement. It provides a pleasant social experience and a means of growing professionally by active participation. Professor Robert T. Howe of the University of Cincinnati is Chairman of the YET Committee.

► The preliminary report of the ASEE Committee on Evaluation of Engineering Education has been sent to committees in all of the participating engineering colleges throughout the country and also to deans of engineering colleges. Comments and recommendations are invited. These should be sent to Professor Dan Pletta at Virginia Polytechnic Institute, who is Secretary of the Committee. A summary of the Report appears in the November, 1953 issue of the Journal. The Revised Report of the Committee will be drafted shortly after the first of February.

► Again may we remind you of the six summer schools to be sponsored by ASEE this year. This is the largest number of

summer schools ever sponsored in any one year. These include summer schools in:

a. Machine Design, sponsored by the Mechanical Engineering Division;
b. Graduate Studies in Engineering Mechanics, sponsored by the Engineering Mechanics Division;
c. Humanistic-Social Studies;
d. Engineering Economics;
e. Electrical Engineering;
f. A summer school sponsored jointly by the ASEE Division of Educational Methods and the General Electric Company.

► The Local Committee at the University of Illinois is busy planning facilities and entertainment for the Annual Meeting this year. Professor Lisle Rose, Chairman of the Local Committee, and incidentally also Chairman of the ASEE Public Relations Committee, is doing an excellent job on both fronts. He recently underwent an operation and is convalescing. We send him our best wishes for a speedy recovery.

► If you wish to submit nominations for either the Lamme Award or the George Westinghouse Award, you can obtain brochures describing the awards from the Secretary of the Society. The final date for submission for nominations is February 1, 1954.

► Again may we remind young teachers of the YET Paper Contest this year. The rules were published in the October and November issues of the Journal.

► The ECRC is preparing a policy statement as to why an engineering school should have departments of research, experiment stations, or research institutes. This will be presented for consideration by the ECRC at the Annual Meeting.

Vice President Walker also reports that the ECRC is preparing a survey on the financial policies of research in engineering colleges to determine the practices regarding overtime work, extra pay, and division of teaching and research loads.

► The Committee on Constitution and By-Laws is preparing a final draft of the proposal for an increase in Society dues. The proposal is to establish dues ceilings of $10.00 for members 36 years of age or over and $7.00 for members under 36 years of age. The dues for the first year after adoption of the amendment would be $8.00 for those over 36 years of age and $6.00 for members under 36 years of age. There will also be a provision that the dues are not to be increased by more than $1.00 per year after the first year.

Since 1946, the Cost of Living Index has approximately doubled. There is no way the Society can avoid these rising costs. Until last year, the Society maintained a balanced budget by rapidly expanding its membership and seeking increased advertising in the Journal. But these activities in themselves have entailed increased operating costs.

► It is with regret that we note the passing of Dean Harry P. Hammond. Dean Hammond was one of the truly great leaders of engineering education. He was always a quiet and humble individual, but his influence was both deep and profound. He worked with Dr. Wickenden in the preparation of the "Report of the Investigation of Engineering Education" and was one of the principal individuals involved in each of the subsequent reports, "Aims and Scope of Engineering Education" and "Report of Investigation of Engineering Education After the War." It is not often that a man of his depth of vision and insight comes along. The Society has been indeed fortunate to claim him as a leader and friend.

► The October and November issues of the Journal were a little delayed owing to last minute changes in material to be published. We should be back on schedule with the January and subsequent issues of the Journal.

Our best wishes for a Happy and Prosperous New Year.

ARTHUR BRONWELL, *Secretary*

On Engineering Integrity

By THE COMMITTEE ON THE PROMOTION OF ETHICAL STANDARDS, AMERICAN SOCIETY FOR ENGINEERING EDUCATION

In June, 1952, the General Council expressed concern about the condition of ethics in the engineering profession, and especially concerning instruction in ethics in the colleges of engineering. The president appointed a committee to investigate the matter, and the committee has since been constituted into a standing committee of the Society. The committee has submitted the following preliminary statement which is designed to be a basis for its future projects. In order that the work of the committee shall be adjusted to the viewpoints of engineering educators and members of the Society, all are urgently requested carefully to read this statement and to send written comments to the Editor.

Are engineers getting careless about their ethics? Are they willing to "cut the corners"? Are they beginning to sacrifice "just a little" honor to gain dollars? An outright answer is neither easy nor, perhaps, possible.

For one thing, does the question refer only to the accepted standards of decent conduct which should govern all men, regardless of their state in life, whether engineers, physicians, merchants or mechanics? Or does the question likewise refer to the codes of engineering ethics, such as those published by the Engineers' Council for Professional Development, and by the Founder and others of the older engineering societies?

Again, judgment in the matter should possibly be qualified because engineers are expanding their activities so rapidly. The engineer of a hundred years ago performed comparatively simple tasks. He designed, and supervised the building of harbors, canals and railroads. But during the past twenty or thirty years, engineers have introduced their power and their devices into factories, homes, schools; and into every city, town and village in the civilized world. Is it fair to judge engineers quite as severely as some other profession whose responsibilities have changed little in a century or two?

Further, the objective standards of morality remain fixed, but what people call good deportment today may differ from what they called good deportment in 1910. Men's interpretation of the moral code is severe and lax through successive cycles. Many thoughtful people feel that public scandals, bribery, self-seeking and juvenile delinquency mean that interpretation of the moral code is on the down grade at the moment. If this is so, shall we be content if the integrity of engineers disintegrates no faster than the common rate of disintegration? Or shall the engineering profession be judged strictly according to objective, permanent moral standards?

Finally, shall engineers be held responsible for the way men use their machines and structures? For instance, it is obvious that the automobile is a direct or an indirect instrument in very many crimes. Shall automotive engineers merely shrug their shoulders and remark, "We can't help it if the people don't make proper use of the cars we give them"? Or must they assume at least a portion of the responsibility for criminal use of automobiles? These are some of the reasons why it is not easy to say whether or not the integrity of engineers is deteriorating.

Because this problem of engineering integrity is so involved, the Committee did

not think that the question could be adequately investigated by any kind of formal research, or by means of the more or less despised questionnaire. Hence, the Committee wrote to engineering educators, prominent engineers, and others who are in a position to see what is going on in the community. The Committee requested the correspondents to express their viewpoints about the integrity of engineers.

The correspondents replied as follows:

	Engineering ethics holding up well	Ethics deteriorating	Some misgivings	No comment
Editors, publishers of metropolitan American newspapers	8	0	1	1
Editors, national general magazines	1	0	0	4
Editors, technical journals	4	0	0	0
Presidents, officials, industrial corporations, mostly nationally known	23	0	4	4
Presidents, secretaries, national engineering societies	10	4	0	1
Engineering educators	19	8	0	5

Most of the correspondents clearly had in mind only general moral standards, and gave no thought to formal, professional codes. But some of the presidents and secretaries of the national engineering societies seemed to orient their replies at least in part to the codes of ECPD or of their own societies.

A casual survey of this kind obviously cannot be conclusive. But the correspondence seems to indicate that it is principally the engineering educators and the officers of the national societies who are worried about the ethics of engineers. In fact, a number of non-engineering correspondents went out of their way to commend engineers for their high moral standards and deportment.

Individual Comment

A number of correspondents made interesting comments.

Several pointed out that engineers are not as severely tempted as other professionals because they work mainly with the materials and forces of nature, and the laws of nature simply cannot be tampered with.

A manufacturer, an airline official and a prominent engineering dean agree that the integrity of engineers is above reproach, but they find a general weakening of the moral fibre, a seeking for easy living, not only among engineers, but in the whole community. The dean wrote:

> I find that there is a very strong tendency to seek security, for example, at somebody else's expense, when we all should realize that the only real security is a man's value to the community.

One important manufacturer said that

> It seems to me that there is evidence of a reawakening of spiritual values in this country, and a consequent rise in our ethical and moral standards. . . . I am optimistic enough to believe that increasingly we, as a people, will find wisdom and fortitude to meet them (responsibilities) effectively.

On the other hand, another engineering dean struck a note of pessimism:

> I do not think that the integrity of engineers is deteriorating any faster than the mass of American people who have been cut loose from their religious moorings and are drifting on a sea of secularism without a moral rudder or compass.

A third dean joins him and feels that

Apparently the young graduates go out with a reasonable standard but they soon find that the consulting engineers and contractors with whom they work are frequently, if not regularly, contributing for political favors. As a result of this, their ideals become converted to the "practical approach" which leads to dishonest practice.

A respected engineer with eighteen years' experience in a certain field of industry contends that he has direct and personal knowledge of many cases of "contributions," "funds," "cooperation," "arrangements," and "kick-backs." He reports that such practices are common in municipal, state and federal projects or undertakings.

Engineers who pretend to be informed acknowledge that bribery and dishonesty are not unusual in this same field of industry. But they insist that the professional engineers engaged in this field have consistently succeeded in preserving their own integrity.

Two divisions of ASEE devoted a portion or all of one joint session at Dartmouth College in June, 1952, to a discussion of this very field of industry and its ethical problems.

More gratifying is the comment from both the president of an important automobile manufacturing corporation and the president of a strong labor union. They say that the state of engineering integrity cannot be too bad when the engineering educators are worried enough about it to appoint a committee.

The Committee believes that the situation can be appraised about as follows:

1. The great majority of engineers are ethical.
2. A small minority of engineers are engaged in a certain field of industry in which corruption seems to be common. To say the least, these engineers must be subject to serious temptation.
3. The American people regard engineers as highly ethical.

Responsibilities of the Colleges

What are the responsibilities of the engineering college faculties? This is doubtless the key question in the entire discussion. Do engineering educators have to turn out students with sound moral judgment? Or can the engineering teacher excuse himself and remark, "Engineering is applied science. My job is to teach heat transfer (for example) and how to make the knowledge of heat transfer useful in business. Let the parents, the churches, and the schools train the boys to behave themselves. That is none of my business." It does appear that the engineering colleges are responsible for showing students the difference between right and wrong. If some of the students have learned it elsewhere, well and good. It is equally the responsibility of the colleges to demand ethical conduct of their students.

The colleges prepare young men for the engineering profession. They do not pretend to make professional engineers of the students. But they do pretend so to condition the students that they can learn to become professional by means of practice and experience, or in part by advanced study in the graduate schools. Moral judgment is one of the qualifications a young man should possess when he stows away his diploma and rolls up his sleeves to go to work in plant or office; or in the graduate school.

In the Report of Investigation of Engineering Education, Dr. William E. Wickenden, distinguished spokesman for engineering education, declared that one of the attributes of "group professional life" is

A standard of conduct in relation to clients, colleagues and the public, based on courtesy, honor and ethics.[1]

After graduation the engineer learns to do engineering work: estimating, development, selling. People then expect him to use ethical judgment. Nobody will have the time or the patience to teach him what

[1] II, Part 1, 1108.

he should have learned long ago. If he can't tell right from wrong it may very soon go hard with him.

The engineering faculties must teach ethics, specifically. In spite of some opinion to the contrary, understanding of ethics does not follow from understanding of science and technology. A brilliant student of physics or refrigeration may be a crook. As Mr. T. E. Murray stated in "Some Limitations of Science,"

> Science cannot save men from themselves any more than society can. Rather it is individual men who must save society and themselves. If they will not live by virtue, they have to die by power.[2]

Aims and Scope of Engineering Education

American engineering educators have committed themselves to the teaching of ethics. In June, 1940, The Committee on Aims and Scope of Engineering Curricula presented its report to the Society in its annual meeting at the University of California. The Society approved and adopted the report. Engineering educators treasure this report as an admirable statement of their duties, ideals and aspirations.

In this report the committee states that one objective of engineering education is

> Development of moral, ethical and social concepts essential to a satisfying personal philosophy, to a career consistent with the public welfare, and to a sound professional attitude.[3]

Engineering educators have thus accepted the obligation to teach their students ethical judgment. If they desire relief from this responsibility, they must first repudiate the report of the Committee on Aims and Scope of Engineering Education. They have no other choice.

Moreover, if the colleges decline to instruct students in ethics, who is going to tell them about the ethical codes of the profession? Where will they learn about the Canons of ECPD, and the special codes of the Founder and other societies?

Let us grant, for the sake of argument, that parents, school teachers and pastors should train boys to be upright before they ever register as college freshmen. But how can parents, teachers and pastors inform boys about professional codes? And whom are they to inform? How can they know which boys will become engineers? If the young engineer is to learn about the professional codes it will clearly have to be in his college.

Of course, the teaching of ethics is not the exclusive task of the colleges, except for the professional codes. Training young men to be upright is a continuing task. Parents should begin the job, school teachers and pastors should carry it on, and the college faculties should complete it.

Whether integrity among engineers is improving or deteriorating really has no bearing upon the responsibilities of engineering educators. It is their task to instruct students in ethics and to require students to be ethical in their deportment. If integrity is improving the educator may be entitled to some little gratification. If integrity is deteriorating he must redouble his efforts. In no case may he relax.

Authority and Criteria for Ethics

If engineering educators are to teach ethics, they must know two things: What are the rules or standards of ethics; and by what authority have they been established and promulgated?

These two questions have to do only with general ethics. They do not pertain to the Canons or codes of professional engineering ethics. Nor is the Committee concerned with the whole system of morality. The Committee obviously has nothing to do with burglary, arson or homicide. The Committee is concerned rather that engineers shall strictly and delicately regard the personality and the well-being of those whom they encounter in their work. The Committee is further con-

[2] *Electrical Engineering*, LXXIV (February, 1952), 125.

[3] *Journal of Engineering Education*, *XXX* (March, 1940), 564.

cerned that engineers shall be intellectually honest, that they shall be generously loyal to the institutions with which they are associated, and that they shall otherwise live up to superior standards of conduct and attitude.

Fortunately, persons of superior education and background, engineers and others, very largely agree upon what is right conduct and what is not. Cultivated and refined men spontaneously approve an act that is generous, and condemn an act that is mean or dishonest. It is a matter of conscience. But conscience is not the exclusive prerogative of the elite. All men spontaneously judge right from wrong. Every man praises and blames over and over every day, and every time he does either, he voices a decision of his conscience.

Most engineers agree as to what is good conduct and what is not. But neither engineers nor others seem to agree about the criteria or the authority for ethics: "The rules seem right to me but where did they come from? Who put them together? What right has he, whoever he was, to tell me what I am to do and what I can't do?" The question is important. If there is no authority, no criterion, men who incline to evil may revise the rules at any time, so that vice shall no longer be vicious. There must be criteria for reference.

Men who are interested have recognized various criteria or authorities, very often with deep conviction and enthusiasm. Some of these criteria or authorities are the following:

Feeling

Feeling means different things to different people. The erratic impulses of an emotional person can hardly be a safe norm of good deportment. The impulses of a mob are a dangerous guide of conduct. On the other hand, the decisions of conscience are called feelings by some people, although many reputable philosophers contend that they are intuitive intellectual judgments. This much is certain, the moral judgments of a responsible man are consistent; they conform to a pattern, whether they result from feeling or from judgment.

Good Taste

There are cultivated and refined men and women who deport themselves ethically, but apparently decline to recognize any moral authority whatever. They are not sure about right or wrong, but they adhere to a code of good taste, "the thing to do." Their standard of good conduct is that which is approved by the "best people." Their standard of evil conduct is that which is vulgar or offensive. By good deportment they practically mean good manners, and by an upright man they mean a gentleman.

Scientific Research

The methods of the physical sciences have been eminently successful in their proper field. These methods have acquired impressive prestige from their success. As a result it has become the fashion to insist that everything men do must be subjected to and governed by research, and to hold that there is no truth except the "facts" which are established by laboratory type experiment. Those who hold to this opinion give to prevailing moral standards only tentative support, against such time as scientific investigators shall evolve a new system of morality. However widely held and respectable, this approach seems to be at least open to question. As Dean Hugh Taylor of the Graduate School of Princeton University has explained, the

> . . . sciences provide answers as to observed behavior; but they do not answer the question whether such behavior is right or wrong. The whole area of ethical judgments or conclusions lies outside the province of these sciences. They cannot answer the question: should I do this? Ought I to do that?[4]

[4] *Religious Perspectives of College Teaching in the Physical Sciences.* P. 25. *New Haven: The Edward W. Hazen Foundation, undated.*

Golden Rule

Very many people refer all their problems and perplexities of deportment to the Golden Rule: "Do unto others as you would that they do unto you." Generous and high-minded men have thought the question through and find the Golden Rule best suited to their outlooks and temperaments. Others are too busy (or too lazy) to think about the question at all, and instinctively feel that the Golden Rule cannot lead them astray. The Golden Rule is doubtless a satisfactory basis of morality for those who are unaffected and kindly, and eager to "be right."

Natural Law

The natural law is a logical basis for ethics and morality. Philosophers of the Western world have studied and observed the nature of man. From their study and observation they have evolved the natural law to meet the intrinsic needs of human nature, and to perfect the character of man, both as an individual and as a member of his community. Natural law requires people to be virtuous: honest, just, temperate. Natural law is the foundation of the systems of positive and civil law.

But only the expert, and perhaps not even he, can readily understand the natural law. It is not easy to interpret Aristotle, Cicero, the Stoics, Augustine, Thomas Aquinas and others who have proclaimed the natural law. It is so difficult indeed that there seems to be no concise, practical moral code which the ordinary citizen can grasp and obey, and which has been derived exclusively from the natural law. Of course, highly intelligent and thoughtful individuals may study the natural law and construct their own moral codes. The chairman of the board of an important automobile manufacturing corporation wrote the Committee that engineers

> . . . must realize that proper moral judgments cannot be made without wisdom; and wisdom imparted by a knowledge and love of God, and by a thorough grounding in the humanities of the great Western tradition. It is from these sources that guidance must always come.

This chairman undoubtedly knows something about the natural law.

Tradition

Many persons feel they are on safe ground when they conform to the viewpoints of the leading thinkers over centuries of time. "If all respected people, or nearly all, agree about something, and always have, they can't be far wrong." The peoples of the Western world have adhered to a consistent standard of ethics during nearly twenty successive centuries. This consistent standard is based on the natural law. Mr. Winston Churchill meant this Western tradition of ethics when, at the Massachusetts Institute of Technology in 1949, he spoke of

> . . . our inheritance of well-founded, slowly conceived codes of honor, morals and manners, the passionate convictions which so many hundreds of millions share together of the principles of freedom and justice . . .

Religion

Religion may well be the strongest motive for right conduct. All religions of the Judaeo-Christian system prescribe the Ten Commandments. There are people, of course, who deport themselves correctly, without subscribing to any form of religion. But if the experience of centuries means anything, the great majority of religious persons can be depended upon to be ethical. To worship the Creator, and to have a high regard for one's fellow man as the likeness of the Creator, seem to have inspired most of the personages whom history recognizes as especially high minded and ethical. Men who have all their lives been active members of religious denominations invariably and justly are expected to be upright in their dealings with fellow citizens. In fact, this is so much the case that it is considered especially disgraceful when a church mem-

ber fails to live up to accepted ethical standards. By the practice of religion are here meant reverent and sincere religious observances, not merely to go to church as a social gesture or custom.

Review

When a man deports himself in such a manner as to win the approval and respect of all who know him, it may be all but offensive to raise a question about the criteria or authorities which sustain his code of ethics. However, an acceptable code of ethics may derive from a faulty premise. Hence, it appears to be the Committee's duty to review the criteria and authorities for morality which have been enumerated and discussed, and to make proposals regarding them.

As a criterion or authority for universal systems of morality, the Committee is of the opinion that:

1. Feeling is unreliable because essentially unstable.
2. Good taste is too closely related to good manners, which vary from region to region and from decade to decade.
3. The research methods of the physical sciences are not adequate to the determination of moral right and wrong.
4. The Golden Rule is satisfactory, although selfish men will reject it.
5. The natural law is a sound basis for morality. Its only, but serious handicap is that it is difficult to interpret.
6. Tradition and history of the Western world are acceptable since they represent an exceedingly wide range of human experience.
7. Religion is likewise a sound basis for morality. But its handicap is that too many of the people do not practice religion; and too many more do not recognize religion as a guide to conduct.

Accordingly, it seems clear that any general system of ethics must rest upon more than one criterion or authority.

Instruction in Professional Ethics

Students need to learn two phases of ethics: special ethics, which pertains to the status and the practice of professional engineers, and general ethics, which governs the deportment of all people, regardless of occupation or condition. The two are quite distinct although they have many maxims in common.

The obligation of the faculties to instruct students in professional ethics is probably more serious than the obligation to instruct them in general ethics. After all, the teaching of general ethics is a joint responsibility which the faculties share with parents, school teachers and pastors. But there is nobody with whom the faculties can share responsibility for teaching professional ethics.

Instruction in professional ethics should be considerably easier than instruction in general ethics. For one thing, criteria and authority for professional ethics are clear. It is obvious that the professional engineering societies constructed the codes for guidance and control of their members. There can be no question about their authority to do so. The Canons of ECPD are principally, if not entirely, an adaptation to the entire profession of existing codes of the several engineering societies.

Furthermore, basic subject matter for the teaching of professional ethics is no problem. The Canons of ECPD and the codes of the Founder and other societies are available. However, as far as the engineering teacher is concerned, these are no more than outlines. As they stand, undergraduate students could hardly understand them. The Canons of ECPD, for instance, are expressed in general and abstract language. So it is that the professor who stood before his class and recited all the twenty-eight Canons would face only bewildered young men when he concluded. An inexperienced undergraduate who read the Canons, even carefully, would not be much enlightened. The teacher must interpret the Canons to give them meaning, and he must state the

meaning in simpler if more abundant language. There seems to be no prepared text or manual for this purpose.

Neither can the teacher find an adequate supply of cases or other material to illustrate the several Canons. Competent authorities feel that subject matter such as professional ethics is best taught by means of incidents which illustrate violations and graphically describe the harmful results of those violations. Such material might quite easily be assembled. For example, without disclosing names, any state board of engineering examiners could supply accounts of the violations of ethical codes which have been brought before it. Committees on ethics, professional status or responsibility of the Founder and other societies could submit records of cases which they have reviewed. Some years ago the late Professor Daniel Mead conducted a monthly feature in Civil Engineering in which he proposed solutions for troublesome ethical problems. So much for professional ethics.

Instruction in General Ethics

Instruction in general ethics is rather more difficult than instruction in professional ethics. First of all, engineering students may not be much interested in general ethics. In spite of many exceptions, they notoriously take little interest in subject matter not clearly related to the purely technical phase of engineering. Their habits of thinking and working have got them used to steel, steam, gas and concrete. They incline to be uncomfortable when such topics as responsibility, human relations, judgment and aspiration are thrust upon them. Abstractions irritate them. Furthermore, there is a variety of criteria or authorities for general ethics. This variety may confuse the students, or make them skeptical, especially if champions of the several criteria insist that none except their own are valid. The teacher will find it hard to explain that a single and an adequate system of morality can originate from any one of several premises, or even jointly from a number of them. The teacher will find it still harder to persuade students, especially intelligent students, to accept any system of ethics as a set of regulations without explaining the sources from which those regulations derive.

Several criteria or authorities for general ethics may be confusing, but, on the other hand, they may reinforce the teaching. Thoughtful students should be impressed by the circumstance that divergent philosophies may produce largely identical, practical systems of morality. Knowledge appears more secure when it originates from more than one independent source.

As far as the Committee could ascertain, there is no text in general ethics which is suitable for all colleges of engineering. There are texts in ethics, of course, but they are apparently designed for students who specialize in ethics or philosophy, and such texts are not adapted to engineering students.

Instruction in general ethics will require even more illustrations and incidents than instruction in professional ethics. The student readily understands the professional codes because they relate directly to his chosen profession. But he will find general ethics more perplexing. Fortunately, there is no lack of cases for instruction in general ethics. Indeed, the instructor will find more ethics problem matter in the current newspapers than he can ever use.

The Committee wishes to call attention to a weakness in the case method as it is sometimes used. The method is quite in fashion. Whenever a method is fashionable, too many teachers adopt it enthusiastically without knowing how to use it. Hence, there is a tendency to discuss cases as human interest stories without relating them to the criteria involved.

Instructional Procedures

The question now arises, how is an engineering faculty going to instruct students

in ethics? The obligation to do so is clear, but how is it to be carried out? By means of formal, credit courses, by lectures, by honor systems, or merely by maintaining in the college an atmosphere of honor and integrity?

The easiest offhand answer is to offer credit courses in ethics. But such are not favored in all quarters. The president of an important technical institution, an eminent scientist, expressed astonishment at the mere mention of a course in ethics. Other correspondents share his view. Their attitude is in good repute. Most Americans feel that, however forceful and precise our indoctrination of students in mathematics or physics, or even in democracy or free enterprise, we must never give them positive direction in any matter pertaining to personal deportment.

Others hold to the opposite view: "And why not a course? The only way I know for students to learn a subject like ethics is for somebody to teach it to them, and the more emphatically the better. I don't expect the students to learn structures by themselves, so why should I expect them to learn ethics by themselves? It has to be a credit course. If we give no credit, we practically tell the students that we consider ethics of no consequence."

A few college faculties are convinced that lectures are the best way to teach ethics. Indeed, lectures on professional subjects have long been a feature in a number of colleges and schools of engineering, and the lectures seem to include more or less reference to ethics. These references are probably to professional codes rather than to general ethics.

An exceptional teacher may be able to make lectures effective. He must have a strong personality, and will need to be interesting and forceful; otherwise the students will go to sleep.

Courses or lectures alone, however, will never make students ethical. There has to be motivation. In his contribution to the Buck Hill Falls conference, Dr. H. S. Rogers declared that

> Within the scope of professional training and perhaps within a program of general education, time does not permit the attainment of any high level of critical or philosophical understanding of the good man and the good citizen. Many examples, furthermore, of immoral and unsocial conduct on the part of the Nazis, Fascists and Communists, well informed in history, can be used to illustrate the gaps between knowledge, beliefs and conduct.[6]

He was not speaking of ethics in particular, but his comment applies as well to ethics as to other humanistic-social subject matter.

The attitude and deportment of the engineering faculty must be faultless if the students are to take ethics seriously. The faculty must strictly observe ethical codes, and must require the students to observe them. This is so well understood that some faculties depend exclusively upon the morale and the atmosphere in the college for imparting ethical understanding. Besides, all the faculty must support the program. The professor who teaches thermodynamics at 10 o'clock must not scoff at the distinguished visitor who insisted on high moral standards in his address before the student body at 9 o'clock.

If ethics is to be taught either in courses or by means of lectures, the instructor will need to be exceptionally competent. He will be either an expert in ethics or philosophy who is interested in engineering students and education, or an engineering teacher who has made ethics a special study or hobby. He must know how to capture and retain the attention of his students, and this calls for unusual enthusiasm and inspiration. Furthermore, he will need a sense of consecration to a special mission. He will have to do the work largely for the love of it.

The instructor will probably be most successful if he proposes a system of

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[6] "Gaps Between the Statement and Achievement of Objectives in the Education of the Engineer," *Education for Professional Responsibility*, pp. 45–46.

morality to the students and then relates it back to its origins. In this kind of subject matter, he will be less effective if he follows the more logical method of working from the premises down to the system or code.

Curriculum Revision

If there is to be a credit course in ethics, where is it to be inserted into the crowded curriculum? Some other courses will need to be eliminated. However, if the faculties are fully aware of the importance of ethics, and of their obligation to teach it, they should have no serious difficulty. The Committee studied curricula as published in the bulletins or catalogs of many colleges of engineering and discovered the following courses offered in various institutions. In the opinion of the Committee, ethics might well be substituted for any one of them:

Anthropology
Background of Contemporary Civilization
Background of Democracy
Cultural Elective
Development of Western Civilization
Human Engineering
Industry and the Individual
International Relations
Management and Labor Relations
Modern Civilization
Non-technical Elective
Social Science
Survey of the Humanities
United States in World Affairs

But as explained, all this applies only to those faculties who choose to teach ethics by means of formal, credit courses.

Whatever method the college uses, it is essential that the faculty bring the method to bear on all the students. The faculty is responsible for imparting to all students an understanding of ethical values. This responsibility cannot be carried out if students can be absent with impunity from whatever exercises have been prescribed, or if faculty or students are permitted to violate ethical codes.

The Committee is not yet prepared to recommend any one method in preference to others for imparting ethical understanding to students. Conditions are too different in the colleges and schools. Lectures may be feasible in one college, courses in another, and tradition in a third. Each faculty will make use of whatever special resources are available. In a well known school of engineering, "The honor system covers not only such things as unproctored examinations but also complete reliance on the honesty of students and faculty in all academic matters as well as in all campus activities. Thus, for example, personal property has always been perfectly safe anywhere on the . . . . . campus." This school clearly possesses an excellent apparatus for inculcating ethical understanding. Other institutions have strong departments of philosophy. Still others are religious foundations with influential religious atmospheres. Each must be utilized for ethical instruction.

The important matter is that the faculties take their responsibility for ethics very seriously, organize and work dutifully to meet this responsibility, and institute reliable checks to make certain that the responsibility is fully executed.

Conclusions

The Committee feels that it has completed a reasonably correct review of the condition of ethics in the engineering profession and in engineering education. The Committee was appointed only nine months ago. Obviously, the Committee has made no comprehensive or scholarly investigation, such as a company of experts and statisticians might complete in a year or two. The members of the Committee are all active in their respective positions and occupations. This statement of the Committee is the result of such careful and diligent inquiry and consideration as the members were able to accomplish in addition to their regular duties.

As a result of its study, the Committee believes that:

1. Most engineers are ethical.
2. Engineers have an excellent reputation for integrity with the general public.
3. There is a tendency among engineers, and among others in the community, to decline to accept responsibilities; which does not imply that engineers fail to carry out responsibilities which they have accepted.
4. There is evidence of a degree of corruption in a certain field of industry. While the individual engineers in this field may have maintained their integrity, they must be subject to temptation.
5. Engineers should understand and comply with both general and professional codes of ethics.
6. Standards for general ethics should derive from several criteria or authorities.
7. Criteria exist for both general and professional ethics.
8. Insufficient illustrative material is available in organized form for instruction in ethics.
9. Engineering educators are responsible for instructing students in ethics, and for motivating them to comply with ethical codes.
10. Very few colleges or schools of engineering have introduced formal or specific measures for ethical instruction.

Recommendations

The Committee proposes the following recommendations:

1. That the faculty of every college or school of engineering be concerned with instruction of all students in general and professional ethics; and with their motivation so that they will comply with ethical standards after graduation.
2. That this concern of the faculty be implemented by such specific and formal measures as may be most appropriate to the traditions, organization and operation of the individual institutions.
3. That promotion of ethical standards in engineering education be recognized as an element in the objectives of ASEE, and that a permanent organization be created, in the Society, and permanent activity undertaken, in order to achieve this objective.
4. That one such activity be the organization of subject matter and reference material for ethics instruction.

Acknowledgment

The Committee wishes to express its appreciation to officers, Council and staff of ASEE, and to many engineers, educators, engineering society officials, industrialists, editors and others. The Committee would have been helpless without their information, their viewpoints, and especially their encouragement.

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C. J. FREUND, Chairman
University of Detroit

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An extended bibliography has been prepared by the Committee and copies will be available to anyone who wishes to request one from the chairman.

The Echelons of Engineering Education

By

K. L. HOLDERMAN, *Director, Dept. of Engineering Extension*
J. W. BRENEMAN, *Professor of Engineering Mechanics*
ERIC A. WALKER, *Vice-President, ASEE; Dean of Engineering*

The Pennsylvania State College
State College, Pennsylvania

The year 1952 marked the formal centennial of American Engineering. We now enter the second century of this modern technological era. Yet the grains of sand in the hour glass of eternity move very slowly indeed when compared with the rapid and complex scientific advancements of the last few decades. The science of engineering in the United States has developed from infancy to a mature position of great importance during the past one hundred years. Engineering education has played the dominant role in this phenomenal growth.

America's genius for production has been achieved by the education and utilization of large numbers of trained scientists and engineers. A democratic society providing more and more higher education for a greater number of people has made this possible. Yet engineering education is a mere neophyte compared with the older formal educational disciplines required for the learned professions. In 1870 there were but six engineering schools in this country, providing training for only three hundred graduates each year. Since then, the rapid and widespread growth of public institutions of higher learning has contributed considerably in bringing about this country's engineering and industrial accomplishments. The founding of municipal and state universities and the establishment of the widespread system of Land-Grant colleges have made possible a hundred-fold increase in engineering education in but eighty short years.

During most of this time, since 1893, engineering educators have been banded together in what is now the American Society for Engineering Education to work cooperatively and intelligently in the general interest of education. The process of educating engineers in the engineering schools of America has received a great deal of study. Generally speaking, this study is the major purpose and continuing objective of the Society. However, there have been, from time to time, specially-designated committees assembled to make up-to-the-minute reviews and recommendations for the betterment of our educational system—either through improvement in teaching, curriculum content, or facilities.

The first significant study was made in 1929 when engineering education was little more than seventy-five years old (1). At that time, Wickenden pointed out that the "higher forms of technical education have developed sporadically in the United States and without an underlying plan." He then went on to say that one type of engineerig education, viz., the four-year curriculum with lectures, recitations, and laboratories, has tended to develop to a point of domination. At the same time, there was a marked difference between the product of American schools and those graduating from the European technical colleges. Some of the difference resulted from the influence of the Land-Grant

College movement which tended to make education available to all those who could profit from it, but at the same time tended to make our American engineering education of the more practical variety. Wickenden went on further to say that European schools had found no substitute for our curriculum or our specialization, but in the teaching process we seemingly lagged far behind. "In nothing does the essential juvenility of our higher education reveal itself so fully as in the textbook, daily assignment, recitation, written quiz, piecemeal grading system of instruction, and in our eager effort to compensate for the students' defective mastery of the processes of learning by one and another pedagogic device."

Unfortunately, little if any change has taken place in this respect in the more than twenty years since Dr. Wickenden's report was published. The report further pointed out that our instruction in industrial management was more advanced than that in European schools and that much interest was being shown by many European educators in our accomplishments in this area. Most important of all, it was pointed out that our education stressed the art of engineering and not the science. Our curricula contained too many courses in drafting, shop practice, and "how to do it," and not enough in science and the fundamentals of engineering. This was emphasized by the realization that American industry, when seeking engineers who could make important contributions in the design of new and better equipment, usually looked to Europe and not to the graduates of our own engineering colleges. It was also admitted that many American universities, too, sought European scientists for the more important and better teaching positions. Obviously, something was wrong. Slowly changes were brought about by educational planning. Gradually, the art-type of courses have been dropped from our curriculum and replaced by more fundamental courses in mathematics and science. This has been fortunate since changing times and a changing world have now made it quite necessary for us to be self sufficient in preparing our creative engineering manpower.

Again, in 1939, spurred on by criticism from many industrial leaders that our engineering graduates were deficient in their use of English and by the universal realization that engineers were not assuming their proper place in industrial or civic affairs, a special committee of the Society, meeting under the chairmanship of Dean H. P. Hammond (2) reported: "First, broadening of the base of engineering education, now in process, should be continued. Its roots should extend more deeply into the social sciences and humanities as well as into the physical sciences in order to sustain a rounded educational growth which will continue into professional life." The report went on to enumerate the objectives of the "scientific-technological studies" and the "humanistic-social studies."

Profound Influence

In the main, the important recommendations in this report have been followed and have had a profound influence on the curricula of American engineering schools. There is now much evidence to show that well-rounded individuals with a command of the English language and an understanding of the world around them are being graduated from engineering colleges and further that the engineers compare favorably in this respect with the graduates of liberal arts colleges and other professional schools.

In 1944, a third major evaluation was made through the sponsorship of the ASEE, once again under the chairmanship of Dean H. P. Hammond (3). This study pointed out quite clearly that as engineering becomes more technical and dependent on a broader base of science, the curriculum ought to provide for both the students who are well qualified scientifically as well as others who could engage in less-demanding types of engineering work. This report reiterated that the

four-year curriculum should be retained with two stems—the scientific-technological and the humanistic-social. Among other things, it also recalled an important recommendation from the Wickenden-Spahr report (4) that subprofessional technical education and training be instituted in a vigorous manner.

"It has been said that the development of technical education in this country has been so preponderantly among engineering colleges that the aims, objectives, and purposes of programs of education and training at all levels—secondary, vocational, technical institute, collegiate, and postgraduate, have become confused. Of these several divisions of technical education and training, programs of technical institute type are the ones that are less adequately recognized and provided for in comparison with others in this country. Yet it is these programs that bear the closest relationship to professional engineering and should perform the most essential function auxiliary to it. This situation is unique among the great industrial nations of the world. Until the problems of training of technical institute type are solved, the aims and purposes of collegiate engineering education are bound to be obscured. For the benefit of industry and society at large as well as of the engineering profession, it is highly desirable therefore that there be widespread recognition and development of programs of technical institute type throughout the country."

"One step that appears to be essential in this connection is the provision of means of formal recognition for institutions offering programs of technical institute type and for their graduates. At present, neither the national engineering societies, nor engineer-registration boards, nor federal civil service, grant any credit in evaluating qualifications of individuals for the completion of educational programs offered by sound institutions operating in this field. The committee believes that industry and the engineering profession should give united support to measures of recognition of sound technical institute programs. These should be similar in general nature but appropriately different in details and operation to the accrediting procedures of Engineers' Council for Professional Development as to engineering colleges and to evaluation practice of state boards of engineering examiners as to individuals. The committee believes that such measures of recognition and certification would ultimately bring genuine benefit to colleges of engineering" (5).

Not a great deal has been done to implement many of the recommendations contained in the second Hammond report although a few significant steps have been taken. Some engineering educators have responded to the challenge. It is hoped that others will follow. During the past two years the faculty of the School of Engineering at The Pennsylvania State College has given consideration to the earlier important studies of engineering education and, as a result has recommended the adoption of two new educational programs. One, a four-year curriculum in Engineering Science is designed to prepare men for the more advanced scientific engineering positions or for graduate work. This curriculum is open only to the top twenty-five students of each freshman class and is decidedly an "honors" course. The other program provides two-year terminal curricula intended to prepare engineering associates or technical assistants. These curricula require less mathematics than the conventional four-year curriculum and treat the subject matter more from the "how to do it" point of view. In the Land-Grant philosophy of providing scientific instruction to as many persons as might profit from it at relatively low cost and close to home, the two-year courses will be conducted only at the Penn State off-campus centers in the larger industrial communities in the State.

For more than forty years the School of Engineering at Penn State, through its Extension Division, has been providing a great many practical courses for industrial workers. During that time, evening technical schools have been operated continuously in a number of communities. Since 1947, day technical institute programs of one year's duration have been conducted in a half-dozen off-

campus centers in industrial areas. Careful analysis of the results attained from the School's past and existing Extension programs and study of the curricula offered by other institutions engaged in terminal tertiary education enabled a faculty committee of the School to develop two new two-year technical curricula. To best serve Pennsylvania industries, programs in Electrical Technology and Drafting and Design Technology were created.

After preliminary consideration had been given to problems of curriculum construction, the engineering faculty committee met with two groups of industrial employers. The first of these advisory committees had representation from most of the larger electrical manufacturing concerns as well as important electric

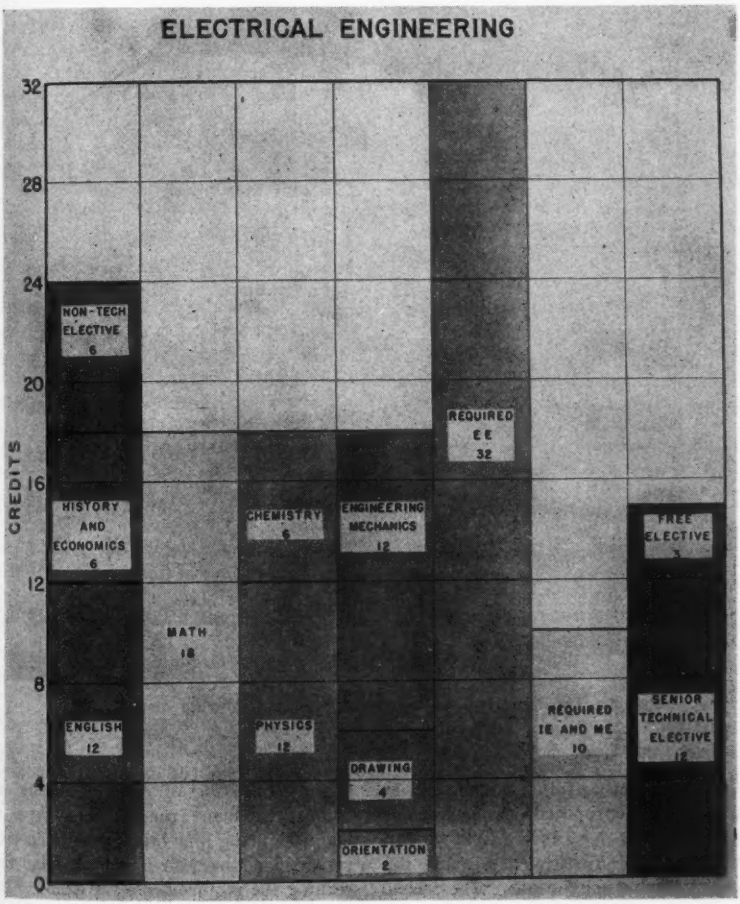

FIG. 1. The Electrical Engineering Curriculum by credits in major fields of study.

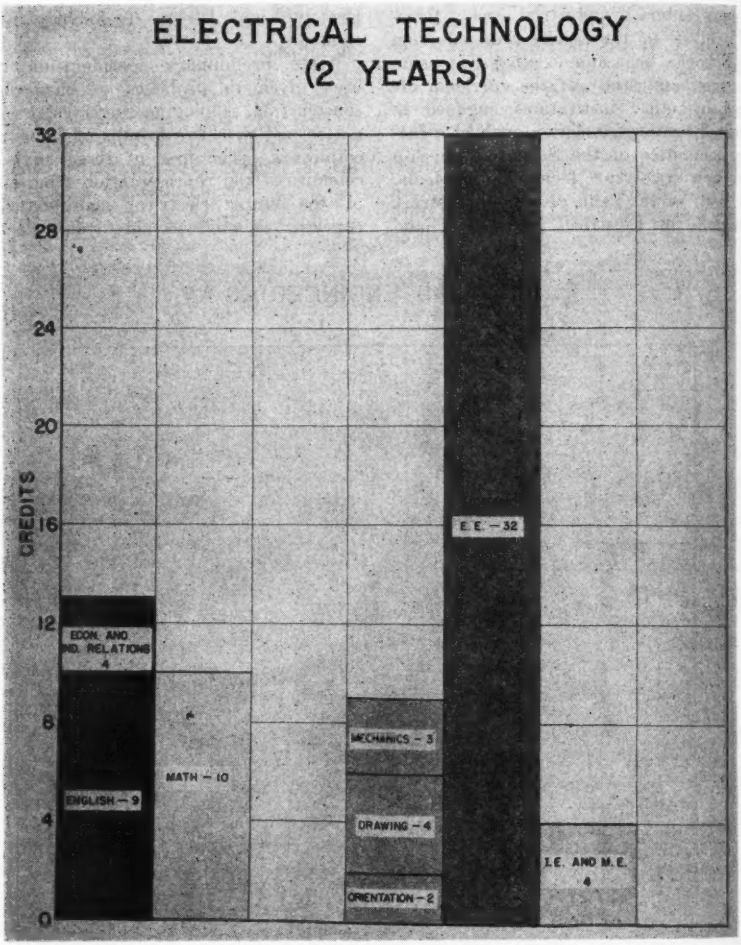

FIG. 2. The Electrical Technology curriculum showing distribution of two years of credit work.

utilities and transportation systems. They evaluated the proposed curriculum in Electrical Technology in the light of current industrial practices and made numerous valuable suggestions. The second committee considered the program in Drafting and Design Technology. This group, consisting of chief engineers and chief draftsmen from various types of manufacturing and fabricating industries, provided a direct first-hand opinion concerning the requirements for drafting and design personnel. The two curricula as finally adopted are in every sense tech-

nical institute in character as defined by Engineers' Council for Professional Development.

The two-year programs consist of courses that might fall into the following five categories: mathematics and basic science; the technical specialty; related technical subjects; English and speech; humanistic-social subjects. In this respect they are comparable somewhat in general composition to conventional engineering programs. An interesting comparison can be made, however, between Penn State's Electrical Engineering curriculum and the two-year Electrical Technology program.

In the Electrical Engineering curriculum (see Fig. 1) fifty credits are devoted to courses in mathematics and basic science. This represents thirty-seven per cent of the entire curriculum. By contrast, in Electrical Technology (see Fig. 2) only fifteen credits of mathematics and science are required, this being twenty-two per cent of the two-year program. Forty-one credits in electrical subjects are taken by Electrical Engineering students. The terminal program has thirty-two credits in electrical courses. Only thirty per cent of the Electrical Engineering curriculum is in electrical courses whereas forty-seven per cent of Electrical Technology is devoted to the technical specialty. Seventeen credits or thirteen per cent of the engineering curriculum are in related technical subjects giving the engineer breadth of understanding while only six credits or nine per cent of the technology program is so spent. Electrical Engineering students take twelve credits in English and speech and fifteen credits in other social-humanistic courses. The two-year curriculum requires nine credits in English and speech and six additional credits in social-humanistic work.

Unique Aims

These important differences in curriculum content reflect the unique aims and objectives of the two-year terminal program. It is intended to be more specific in purpose and not require a broad understanding and application of higher mathematics and basic science. It is designed to prepare the engineering associate to assume many routine engineering assignments and become an important auxiliary in the modern engineering team.

There is one other important consideration that caused the Engineering School faculty to recommend the new two-year programs. During the next ten years, it is inevitable that applicants to engineering colleges will increase rapidly. In the very near future, enrollments will exceed the capacities of existing institutions. Furthermore, from past experience it is reasonable to assume that many of those who apply will not possess the intellectual capacity for professional work. The technical institute is the answer for furthering the training of those with genuine technical interests and aptitudes but limited preparation or analytical ability.

The training of engineering associates and technical aides is an important task to be faced by all engineering educators. Dean S. C. Hollister, in his presidential address (6) to the American Society for Engineering Education at Dartmouth College in June 1952, said:

"As matters now stand, it appears that we have reached a turning point in the profession. With the percentage of the population to be made into engineers no longer on the increase, but with the amount of engineering service needed in the economic system constantly accelerating; and moreover, with the evidence of the disparity of these two situations abundantly evident before us, it now becomes clear that a complete reorganization of the profession must take place over the next few years if the engineering work of the future is to be achieved at the level demanded by our economic system."

"It also becomes clear that in this gradual readjustment three major factors will have to be given special attention:

1. The training of more aides to support the engineers;

2. The change in practice of utilization of engineers by industry and other agencies employing them; and
3. The education of the engineers themselves."

Another past-president of the Society, Dean Thorndike Saville, in his presidential address (7) quoted from Oliver Wendell Holmes' "Poet at the Breakfast Table" in which the author opines that there are "one-story intellects, two-story intellects, three-story intellects with skylights. All fact collectors, who have no aim beyond their facts, are one-story men. Two-story men compare, generalize, using the labors of the fact collectors as well as their own. Three-story men idealize, imagine, predict. Their best illumination comes from above through the skylight." Dean Saville suggested that here we have those who should terminate their post high school education in two years, those who should complete a four-year engineering course, and those who should go on to post-graduate work. He continued by saying, "Let engineering education enlarge its responsibilities and take into the fold as partner, not as step-child, these lusty youngsters." He was referring to the higher institutions offering technical terminal instruction.

For the past fifty years, the School of Engineering at Penn State has devoted most of its resources to the education of "two-story intellects" while at least recognizing that there were floors above and below them. Providing for a complete program of engineering education for Pennsylvanians and Pennsylvania industries is now at hand. Two-year engineering programs will be conducted during the next academic year. At the same time, steps have also been taken to direct attention to the "skylight."

Within the past several years, a number of engineering colleges and universities have developed and made available to undergraduate students curriculums which provide training in the broad field of technical science. Thirty-one different institutions (8) now offer programs in this area of engineering physics which do not differ materially from the Penn State Engineering Science curriculum. Of the curricula now offered at these thirty-one institutions only four (9) have as yet been accredited, two of these in 1949 and two in 1951. This is indicative of the recent developing trend in engineering education to provide programs with a broader scientific foundation that will prepare graduates for research and creative development work in industry or to continue with graduate study in the same basic field.

Following a period of curriculum development and studied approval by the faculty and the Board of Trustees, the Engineering Science curriculum will be initiated in September 1953 at the sopohomore level. During the freshman year, all engineering students follow a uniform course. On the basis of this year's work, the top fifty students are invited to apply for the Science program. Following guidance interviews, twenty-five students are selected as the sophomore group.

Program is Broad

This Engineering Science curriculum is designed specifically to train students who wish to enter the fields of research and development and the other creative aspects of engineering. The program is broader than that of the specified professional curricula and the student is given work in all major engineering sciences with special emphasis on fundamentals and the relationship between the various sciences. This curriculum is more demanding than the others and is expected to be more rigorous. It is definitely an "honors course" for those possessing demonstrated superior qualities.

As shown by the charts, a comparison of the courses required for the curriculum in Engineering Science with those in Electrical Engineering indicates that the emphasis in the former is placed on mathematics and basic technical science rather than on applied courses. The total num-

ber of credits is essentially the same. On the other hand, the two-year Electrical Technology curriculum as shown has a preponderance of time devoted to applied electrical courses with a relatively limited time on mathematics and science.

No attempt has been made to indicate the specific course contents, but the comparison as shown emphasizes the difference in coverage of fundamentals of engineering and the basic sciences in the several curricula.

For those who complete the Engineering Science curriculum and desire to continue with graduate work in a specific engineering field, a minimum of required undergraduate credits would be necessary in fields such as electrical engineering or engineering mechanics; while in others, the courses which would be required to pro-

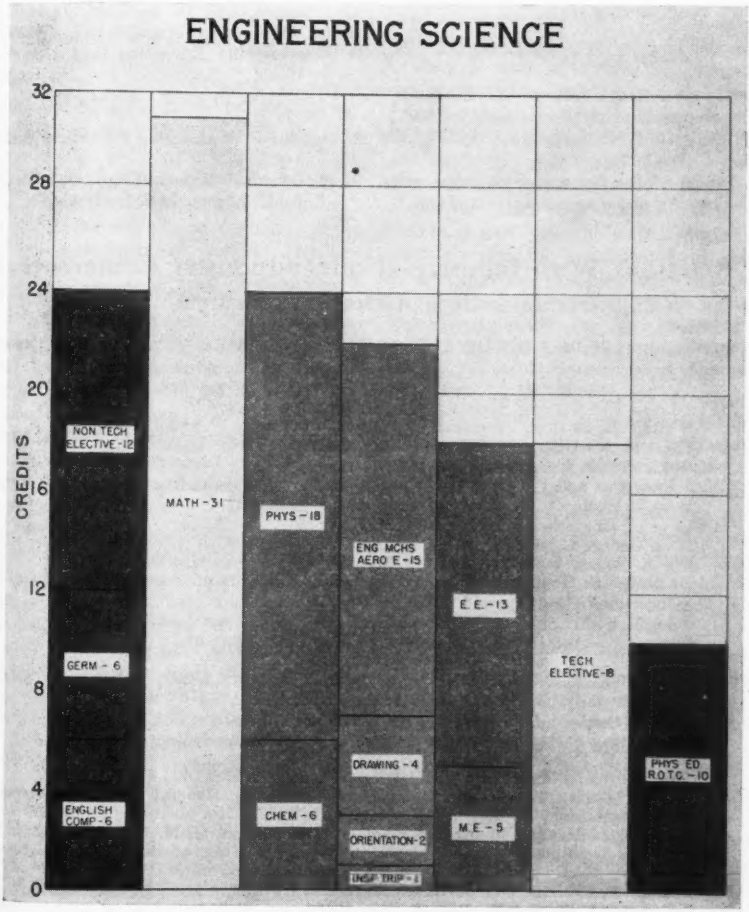

FIG. 3. The Honors curriculum in Engineering Science.

vide the proper background would be fairly numerous.

Industrial employers in Pennsylvania who have been given the opportunity to review the Engineering Science curriculum and who have knowledge of the Technology programs, have indicated their whole-hearted approval and are enthusiastic over the prospect of having an engineering institution recognize the need for educating all echelons of the contemporary "engineering team."

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9. 19th Annual Report, Engineers' Council for Professional Development.

Relations With Industry—College-Industry Conference

Engineering Society of Detroit, January 16, 1954

Keynote Speaker: 10:00 A.M. Col. L. F. Grant, Chairman, ECPD, Toronto, Ont., Canada.
Simultaneous Sessions: 10:45 A.M.
Ten minute talk by each speaker, followed by discussion.

A. "The Local Engineering Societies and the First Five Years."
William E. Stirton, President, ESD, Vice President, Wayne University.
Thos. A. Marshall, Jr., Executive Secretary, EJC, New York City.
Don Jahncke, Ford Motor Company, Lincoln-Mercury Division, Detroit.

B. "The Employer and the First Five Years."
Kurt O. Tech, Ch. Eng., The Cross Company, Detroit.

C. "Colleges of Engineering and First Five Years."
Dean George G. Brown, College of Engineering, Univ. of Mich., Ann Arbor, Mich.
Lee R. Baker, Director, Chrysler Institute of Engineering, Detroit.
Dr. Ralph G. Owens, Dean of Engrg., Illinois Institute of Technology, Chicago, Ill.

D. "The Individual Graduate and his First Five Years."
John J. Uicker, Assoc. Professor, Mech. Engrg., University of Detroit.
Gordon H. Millar, Research Dept., Ford Motor Company.
William Little, Cadillac Div., General Motors Corp.

Address: 1:45 P.M. to 2:00 P.M. L. E. Grinter, President, ASEE, Dean, Grad. School, University of Florida, Gainesville, Fla.

Afternoon Panel Session: 2:00 P.M. to 3:00 P.M.
(Answering questions received by mail or proposed by audience)
Dean C. J. Freund, Moderator.
Fred J. Walls, Manager, Detroit Office, International Nickel Company.
M. M. Boring, Manager, Tech. Personnel Div., General Electric Company, Schenectady, N. Y.
Kenneth A. Meade, Director of Educational Relations, G. M. Corp., Detroit, Mich.
Prof. C. Wandmacher, Head, Dept., Civil Engrg., Univ. of Cincinnati, Cincinnati, Ohio.
Rodney E. Christian, Chief Engr., Kerr Manufacturing Company.

Closing Speeches: J. J. Cronin, Vice President, Charge of Mfg., General Motors Corp., Detroit, Mich.

The National Science Foundation and Its Program*

By RALPH A. MORGEN

Program Director for Engineering, National Science Foundation

In introducing this subject to this audience, it seems unnecessary to review the history of the National Science Foundation, except to say that the Foundation is the organization which was originally envisioned by the Bush report in 1945. The present organization of the Foundation as it affects engineering and the other physical sciences has been described in a staff article in *Chemical and Engineering News*.[1]

This discussion will be confined to a quick look at what is needed for the support of engineering research in educational institutions, touching on (a) what kind of research should be done in the engineering colleges and (b) the subject of how much research should be done in the engineering colleges.

As some in this audience know, this speaker has made a study this year of the needs and desirable methods of support for research in the engineering colleges. Of the 149 institutions which have one or more ECPD accredited undergraduate curricula, replies have been received from 133 institutions. A rather more complete paper based on this study will be published later. It is interesting to note that without exception all 133 replies indicated that both "applied" and "basic" research should be conducted at engineering colleges. Naturally there was considerable disagreement on the definition of the words "basic" and "applied" and the proportions of work in the two areas would vary somewhat on the person's definition of the words. However, after unscrambling all the different definitions of the two words "applied" and "basic" there seemed to be a large majority that agreed on the fact that approximately 50% of those staff members who were engaged in research ought to be interested in basic research and the rest should be engaged in applied research at any one time as an ideal arrangement for an engineering faculty. In addition there seemed to be a rather unanimous agreement that in any given engineering faculty, only about 50% of the faculty would be interested in conducting research at all, the remainder would be interested in doing their professional work outside of teaching in fields other than research, such as writing, consulting work and other professional activities. For the first time then, there seems to be a picture of what would be desirable for the support of "basic" research in engineering colleges. Namely, if the total number of staff members in engineering colleges is known, then support for basic research is needed for approximately 25% of those staff members. The amount of support for any individual staff member will depend largely on that staff member's capacity for doing work himself, directing the work of graduate students and the type of research in which he is interested which would in turn determine the cost of equipment and supplies. This dollar phase of the program will not be pursued further. At this point

* Presented June 24, 1953, Gainesville, Florida, before The Division of Graduate Studies, ASEE Annual Meeting.

[1] *Chemical and Engineering News*, Vol. 31, p. 228, Jan. 19, 1953.

consideration will be given to the relative support among basic research, applied research, developmental work and increase of research plant.

That the support of these various types of research is out of balance is quite evident from the data given in "Balancing the Nation's Research."[2] There it was shown that in Fiscal 1952 Federal support to nonprofit corporations (of which educational institutions represent 88%) was poorly proportioned. Only 21% of the funds went for "basic" research, 50% of the funds went for "applied" research, and 29% of the funds for the support of "developmental work and increase of research plant." It is quite evident that if basic research is the primary function of educational institutions and only ⅛ of the research support by the Federal government is going to basic research, then there is an insufficient amount of funds available for basic research. Even in engineering colleges where 50% of the research should be applied research and 50% basic research, the proportion is far too low. In departments such as physics, chemistry, and mathematics, the desirable percentage of basic as opposed to applied research is 75% or more on the basic side. It is also a fact that engineering colleges are able to get more support for their "applied" programs through industrial sources then they are for the truly "basic" programs. Therefore the Federal government support should lean heavily towards the basic side.

"Basic" and "Applied" Research

At this point there is always considerable discussion as to just exactly what is meant by "basic" and "applied" research programs. At the National Science Foundation there has been an attempt to avoid discussion on the basis of the definition of these words, and to look at the program from a somewhat different point of view. The first consideration that is given to a research proposal is does it answer the following question: "If a graduate student were engaged in this particular research program is it the type of research which the graduate school of the particular university would accept for thesis purposes?" If the answer to that question is "yes," then the chances are that the National Science Foundation might be interested in considering the pursuit of that particular program somewhat further. If the answer is "no," then the National Science Foundation would not be interested in supporting the program. This gives flexibility to the program and allows the university itself to decide on the standards for research. A particular program which might be acceptable for thesis purposes by one institution conceivably would not be acceptable at some other institution. The criterion of whether or not the National Science Foundation should support that program then rests with the university. Is it acceptable to that university for thesis purposes? If so, it is probably the kind of work on which the staff and graduate students should be engaged.

After determining whether or not the research is the kind which would be acceptable to a graduate school the next question that is asked is what is the "motive" of the person who is proposing the research program. Does the principle investigator have in mind a definite or specific application for the proposed research in the form of a machine, device or specific process, or is the principle investigator primarily interested in finding out some new phenomena in nature with the probable utilitarian value either unknown or applicable to a great variety of things? If it is the former then an industrial concern, a federal agency or other organization which is interested in the application should support that particular research program. This decision has no bearing on whether or not it is considered a basic program or an applied program. The decision is based on the application.

On the other hand if there is no specific application in mind then the research might be the type which the National Sci-

[2] Ralph A. Morgen, "Industrial Laboratories," May, 1953, p. 6.

ence Foundation would be interested in supporting. Perhaps a specific example at this point will clarify the matter.

Suppose for example, that a staff member is interested in finding a material which will withstand a high temperature and is suitable for coating the afterburner on a jet engine. In order to develop such a material, a phase rule diagram must be made for a specific system of metallic oxides. The actual research on studying the melting points of a system of several oxides is conceivably basic research in many peoples' definitions. On the other hand the mere fact that this program is aimed specifically at a definite use would indicate that financial support for this program should be obtained from the agency which has primary cognizance over the development of the particular jet engine which is under consideration.

On the other hand another principal investigator is interested in the mechanism whereby films of certain materials become attached to metals and thus may act as a protective coating to that metal. In the course of the investigation that principal investigator must determine the physical properties of certain oxide systems which perchance might happen to be same oxide systems mentioned in the afterburner problem above. However, this particular investigator has no application in mind, he is just interested in the mechanism whereby films composed of oxide materials attach themselves to metallic surfaces. If the answer to that problem could be obtained there would undoubtedly be many applications in many directions. However no applications would be obvious until the mechanisms were determined. That would be a problem which the National Science Foundation might be interested in supporting.

Degrees of Motivation

Naturally there can be many degrees of motivation between the one in which a specific application is clearly and only indicated and one in which the motivation is purely intellectual curiosity. Therefore, the desirability for support for a particular program must be determined finally on the basis of the specific project in mind.

That this philosophy is in agreement with the policies of the present administration is indicated by a letter which the Honorable Joseph M. Dodge, Director of the Bureau of the Budget, wrote to Senator H. Alexander Smith, Chairman of the Committe on Labor and Public Welfare recommending that the ceiling on the research support for the National Science Foundation Act be removed. That letter stated in part "it will be desirable and economical to continue the gradual process of centralizing in the National Science Foundation the general purpose basic research for the Federal Government. * * * For this reason the enactment of S. 977 * (the removal of the ceiling from the National Science Foundation Act) would be in accord with the program of the President." It is clear from this policy statement that the spheres of influence of the National Science Foundation and the various other agencies which not only support research but have a statutory function to perform will be based on (a) whether it is general purpose research or (b) specific research rather than on whether the research is "basic" or "applied" or some other artificial definition.

How Much Research Should College Perform?

The remaining part of this discussion will be devoted to a brief look into the question of how much research an engineering college should perform. From the above it is clear that whatever research the engineering college performs, it should be balanced between applied, and basic. The specific amounts of applied and basic research will vary from institution to institution, depending on the interests of the staff and the needs of the particular locality in which the institution is located.

The other rather important question which needs clarification is the quantity of research which a particular institution

* This bill was passed Aug. 5, 1953.

should perform and thus the amount of dependence it should place on research support from sources of funds outside its usual channels of support. In other words, to be brutally frank, how much contract research should an engineering college take? Here again it is clear that no categorical or specific answer can be given which could fit all institutions. However, there appears to be a general relationship which should be maintained between the normal academic program with funds obtained for this purpose and the research program with its support obtained from more temporary or transitory sources such as a series of contracts, grants, and other forms of limited support.

It would appear therefore that if the ordinary academic budget of the engineering college or engineering division is taken as "x" then the size of the research program "y" should bear a relationship to this figure "x." The size of "y" might show large variations, but should not be allowed to vary without limit. Some relationships between "x" and "y" can be stated in rather general terms. The most important factors in determining the relationship between "x" and "y" is the size of the graduate program and the interests of the staff.

On the one extreme will be the strictly undergraduate engineering college with no graduate program. In that case there should be some research by certain members of the staff, and therefore y, the research budget should be greater than 0 and less than 0.25x. It would usually be undesirable to start a graduate program of any sort until a point were reached where the research program y was of the order of magnitude of at least 0.25x, the ordinary academic budget. With a rather substantial master's degree program and little or no doctoral level work at the institution then y might vary from 0.25x to 0.5x.

When the research program has developed to the point where y is approaching 0.5x then conceivably the time has arrived when a doctoral program might be in order at least in certain departments of the engineering college. As the doctoral program increases in scope and size the research budget y will gradually increase and approach the academic budget x. In the great majority of institutions a one to one ratio of y to x will be very desirable.

There will be a limited number of institutions nationally in which the graduate program far out weighs the undergraduate program in number of students, interest of faculty and other specialized reasons. In that case y the research program might exceed x the academic budget. The danger is that y may continue to increase without limit and the institution then gets in an unstable financial position. There are several institutions in the United States today that have reached what amounts to an unstable situation. It is not believed desirable that y ever exceed x by more than a factor of 2 or 3 and then only in exceptional cases. If y should exceed x by a figure larger than that, then the primary function of the educational institution is in danger of being overlooked. Research becomes the controlling factor with the danger that commercialization may endanger the academic pursuits of the institution.

Summary

Summarizing very briefly, then, two general factors have been discussed at this time:

(1) the kind of research which should be done by an engineering college. That can be succinctly stated as a well chosen mixture of basic and applied research with an eye always to the effect of that research on the graduate program.

(2) a well balanced financial ratio between the academic program and the research program. In general where a rather strong doctorate program is in existence the research program dollar wise might approach the value of the ordinary academic budget.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION

NOMINATION BLANK

"ARTICLE XI, Section 3. (Election of Officers) By means of a form to be printed in The Journal of Engineering Education or in the preliminary program of the annual meeting, an opportunity shall be given to individual members of the Society to submit names of persons to be considered for said officers. These names, on the form provided, shall be sent to the Secretary of the Society not less than sixty (60) days prior to the annual meeting; and the Secretary shall submit the suggested names to all members of the Nominating Committee."

In order to make the election of officers of the Society as democratic as possible, members are urged to fill out the nomination form and return before April 1, 1954 to the Secretary, A. B. Bronwell, Northwestern University, Evanston, Illinois.

I nominate the following members of the Society for officers:

For President .....

.....

For Vice-President .....
(*In Charge of Instructional Division Activities—two years*)

.....

For Treasurer .....

.....

Signed .....

Title .....

Institution .....

Date .....

Sponsored Research in a Large University*

By RICHARD PARMENTER

Coordinator of Research, Cornell University

I have been invited to talk on Sponsored Research in a Large Institution. The institution I know best is, of course, Cornell. I would like to define the dimensions of my subject. Cornell is a University of roughly 9500 students. It is composed physically of eight endowed colleges or schools, and four state-supported ones, at Ithaca; a Medical College and a School of Nursing at New York City; and an Agriculture Experiment Station at Geneva, New York. There is in addition a wholly owned subsidiary—the Cornell Aeronautical Laboratory (C.A.L.) at Buffalo. But this latter is separately incorporated and managed, and will not enter into our discussion today except briefly and then only by specific reference.

The volume of sponsored research at Cornell has risen fantastically since the war. The increase has in fact been 12-fold—from about $790,000 in 1944–45 to $9,451,000 in this last fiscal year.

Of this sum, the State-supported colleges have $5,200,000 or 55%—mostly "budgeted" or "statutory"; the Medical College in New York has $1,500,000 or 16%; the Endowed Colleges at Ithaca, $2,700,000 or 29%.

At C.A.L. there is an *additional* $8,500,000, virtually wholly Government sponsored.

Of the $9,451,000 which will occupy our principal attention, industry supports about 8%, Foundations about 9%, other support 5% and the Federal and State Governments 78%.

Government is thus our largest sponsor. But it must at once be pointed out that ⅔ of Government and State support comes in the form of what I shall term "budgeted" or "statutory" funds. The Hatch Act, Morrill Act, the Bankhead-Jones Act are examples of sources of these research monies which have for many years formed a part of the regular annual budget of the State-supported colleges, leaving to those Colleges a wide latitude in the allocation and disbursement thereof to whatever forms of research seem most appropriate and germane to the interest of the taxpayer.

The remaining ⅓ or about 2½ million dollars comes to the University in the form of Government contract research, and it is this type of support that appears to cause the greatest anxiety amongst educators fearful of Government "domination" of the educational picture. As you can see, it is not excessive at Cornell University, and although this form of support predominates at C.A.L. 150 miles away, its impact is negligible on the campus.

Good and Bad

Such a volume of research has good and bad factors, of course. For one thing, no faculty will stay in an institution which offers no opportunity for research. Research, in balance, makes for better teaching. It affords theses opportunities for graduate students—usually a young man's first emergence into the publication field. And it renders a needed service to the Nation.

Against such obvious advantages are arrayed some equally obvious dangers, to

* An address given before the Graduate Division of ASEE, at the University of Florida, June 24, 1953.

be carefully parried by sound administrative procedures. Otherwise artificial growths in one field, over and above others, may be fostered. There could be a decline in teaching standards. There may arise overdependence upon outside support. Safeguards against these must be set.

Obviously, at Cornell we feel that the blessings of sponsored research outweigh the evils, and the central and all important fact in this conviction stems from our choice of program matter. We have a basic charter which defines the sort of research we are willing to undertake—not just the subjects we are prepared to do research in—but something much more significant—*the definition of acceptability as the faculty sees it.*

These criteria of acceptability are published annually in the report of the Vice President for Research, and while they were embodied originally in an administrative directive of our late President Edmund Ezra Day, they represent actually desiderata formulated and agreed upon by the overwhelming majority of the University faculty. Just as in the case of the University Patent Policy, the Criteria of Acceptability is the result of an operation in Democracy and stems *not* from an administrative fiat from on high, but from the expressed desires of the research workers themselves.

Requirements

The essential requirements of acceptable sponsored research at Cornell are these:

(1) It must be sponsored by—and hence acceptable to—the scientist concerned. *He* initiates the contact with the sponsor, no matter whom.

(2) No faculty member is directed or importuned to undertake any piece of research.

(3) The research must be broad in scope, or broad in method of approach.

(4) The research must be unclassified. There must be free publication not only of the results but of any doctoral theses arising therefrom.

The reasons for these restrictions are obvious; but—it may be argued—this sounds like research conducted in Utopia and not in the United States in the middle of a cold war. How do we get by in our obligations to the Government, for example, if we refuse classified research?

The answer is two-fold. In the first place, we have an equal obligation to the Government to keep our "climate" at its best for adding to the Nation's critically short supply of well taught, well trained, manpower. Classified research in *any* degree, on a University campus, is inimical to the best teaching. Secondly, we *do* assist the Government in its military problems of a classified nature; but we do it at the C.A.L. in Buffalo where 96% of the projects are Government sponsored and most of them are classified. Thirdly, we make our staff available for consultation, when requested, to the absolute maximum of time consonant with adequate fulfillment of their primary obligation as teachers.

Further, we employ a rough and ready rule that no tenure staff member shall spend more than 50% of his time on sponsored research. In this way, pupils who are attracted to the Cornell campus by the prospect of study under a famous teacher will not be disappointed and frustrated by finding on arrival that the great man is immersed in sponsored research, and that his teaching duties have been relegated to less capable hands.

Lastly,—as a further "governor" on the research engine—no one receives additional compensation over and above his academic salary for undertaking sponsored research. The underlying philosophy here is that he has made a free choice and has been under no compulsion to undertake the work, nor has an excessive portion of his time been allocated thereto. It must be obvious that an immense amount of inter-departmental heart-burning and jealousy is avoided by this "no-extra-pay" rule.

Contractual Patterns

The contractual patterns of sponsored research follow roughly these forms.

(1) *The fellowship*—This is a gift to assist a graduate student in the pursuit of studies in a broadly defined field. It is a true gift; and the holder pays no income tax thereon.

(2) *The investigatorship*—Here, the field of research is more or less delimited and a special overseer from the faculty may be designated by the sponsor. Research under this form of agreement often tends toward the applied side. It is a form much used by industry and trade associations, for example.

(3) *The Grant-in-Aid*—This one needs little explanation. It is broad and can cover work in both basic and applied science and carries few restrictions for the worker. Foundations usually allot their funds under such an agreement; but so also do some industries, and certain Government departments, such as the AEC, the NIH, the NSF, etc.

(4) Then there is research done under *contract,* in which the field and subject matter are sharply delimited and some sort of a time schedule—of reporting at least—is set up and adhered to. One cannot speak of contract research without at once thinking of the Armed Services, the NACA, the Rubber Reserve, ONR, etc. Industry more occasionally uses this vehicle of sponsorship.

Impact

Since contract research under Government sponsorship appears to be most closely identified with the fear of an educational system controlled by Government subsidization, I am going to devote a few minutes to consideration of its impact on the Cornell effort.

As I stated earlier, $2,500,000 or 26% of *all* sponsored research at Cornell falls into this category. How and why have we obtained it? How do we man it? How is it paid for?

It is obtained in the same fashion as any other sponsored research—by a direct contact between our scientist and his opposite number in Government. Preliminary discussion may take place at Cornell; at the site of the Government contracting agency; or at a scientific meeting (usually in an air-conditioned bar!). Here, the first ideas are developed and a rudimentary cost estimate is tried on for size. If there is a meeting of the minds, a proposal is formally submitted through the Office of the Coordinator who also signs for the University the resulting contract. *Why* we have obtained any specific contract for research is, of course, implicit in the above. Our man wanted it; the University could house it; and the Government man considered that our people were competent and the price fair.

Once undertaken contractually, the project is staffed by a competent supervisor, aided perhaps by one or two colleagues, and a group of assistants made up largely of graduate students and technicians. The senior men allot a small portion of their research time (never more than a total of 50% to *all* of several projects they may be supervising). The younger men —without University appointments involving tenure—may give part or all of their time to the research. These younger men, of course, are hired on one-year appointments and clearly understand the sources of their employment funds.

The University recovers from the Government the proportionate cost of the manpower involved based on the individual's academic salary, plus an overhead computed on the basis of the "Blue Book." The reimbursement for salaries is used by the institution to supply additional staff to fill any gap caused by diversion of manpower to the project and the overhead is used to cover the indirect costs of the research.

As I have stated earlier, no one gets additional pay for conducting sponsored research. This is a hard and fast rule. Since, however, the faculty of our endowed colleges are on a 9-month year, an agreement with all classes of sponsors

permits a staff member, should he so desire, to be gainfully employed during the summer months on his research project *but not in excess of his normal monthly rate.*

Need Ground Rules

In the good old days, a faculty man did his own negotiating and came up with an agreement that looked good from his own rather narrow point of view. It was a fine system—when the whole operation was small and the cost of living and materials was low—but obviously when a University undertakes research obligations running into millions, you have to use ground rules and some sort of central organization to administer them—as unobtrusively as possible.

At Cornell this organization is headed up by a Vice President for Research and his deputy is the Coordinator. Negotiations for all research in the endowed colleges are finalized in the latter's office and a close liaison is maintained with appropriate offices in the State-supported colleges and in the Medical College.

One fine innovation especially fostered by the Vice President for Research at Cornell, has been the concept of the Research Center—an interdisciplinary gathering-together of talent with common interests across a broad field. Examples are the Housing Research Center, participated in by the departments of Architecture, Engineering, Sociology, Psychology, Economics, Public Health, Home Economics, Labor, City Planning, Public Administration, Law, and Agriculture; the Social Science Research Center is another; the Airphoto Interpretation Center; and the Statistics Center. The presence of such a Center on the campus identifies Cornell with its fields of interest, thus facilitating the raising of research funds. Ideas germinate through active cross fertilization; and last, but not least, of the Center's charms, is the fact that its creation and functioning entails virtually no additional administrative expenses since its housing and staff are already cared for by existing academic budgets. Beyond perhaps an additional secretary or clerk, little increase in personnel is required.

Patent Monies

There is need in a tax-exempt institution for a means to appropriately handle and disburse monies arising in royalties on inventions assigned to the University or on license fees collected under similar agreements. At Cornell this operation is performed by the Cornell Research Foundation, Inc., a wholly owned subsidiary whose Board of Directors is composed of Cornell faculty, administrators, alumni and industrialists. Its two chief officers are the Vice President for Research and the Coordinator. Like the Criteria of Acceptability, the University's Patent Policy represents the considered wishes of the faculty. In general, inventions are assigned to the Research Corporation of New York City for prosecution and exploitation with a small share of the gross going to the inventor and the net profits, if any, being divided equally between the Research Corporation and the Cornell Research Foundation. Each of these latter organizations, by its charter, is obligated to "plow back" these funds into the furtherance of research.

At Cornell University the recipient of patent monies is the Faculty Grants Committee composed of five men from different academic areas, chaired by the Dean of the Graduate School, and with the Coordinator of Research sitting as a member ex-officio. The Faculty Grants Committee we regard as an extremely important body, for the projects which it considers and supports come from areas largely neglected by the sponsors of large, expensive, modern, technological research employing complicated machinery and teams of workers. Here, research is an affair solely of the mind rather than of gadgetry. Supported by these grants—tiny in size perhaps, but rich in cultural implication—we find scholars at their chosen tasks. Here are men serenely working at

research on 16th century polyphonic motets; on a manual of Dragon Flies of North America; on the Life and Works of Daniel DeFoe. This is a pattern of research nostalgic to those of us who are no longer young—the intimate, personal dedicated search for truth—a thing of loving labor and of the spirit, rather than of Univacs and Differential Analyzers. We should indeed be derelict in our primary duty as a University ever to falter in support of this sort of effort.

This then has been the picture of Cornell's answer to the problems of sponsored research. It has been my privilege and pleasure to present it to you. I invite your frankest comments, that in so complex a task we may have the benefit of other experiences and of other points of view.

College Notes

W. R. Turkes, professor and head of the department of industrial engineering at the **University of Pittsburgh**, has been named assistant dean in the Pitt Schools of Engineering and mines.

* * *

A completely new curriculum designed to prepare men for careers in the distribution areas of modern industry will be initiated next fall at **Clarkson College of Technology.** The pioneering curriculum was evolved through cooperative studies by industrialists and educators as broad training for today's needs. By combining the essential elements of the engineering sciences with those of business administration, the new Clarkson Tech curriculum will produce graduates who are uniquely equipped to fill posts of responsibility for which adequate college training has not previously been available. The four-year course will lead to the degree of Bachelor of Science. The major will be in Industrial Distribution.

* * *

A massive windowless laboratory building will go into service soon as new headquarters for **Cornell University's** studies of high-voltage phenomena. The High-Voltage Laboratory, replacing one destroyed in a million-dollar fire in February, 1948, is expected to be in full operation in about a year. Like its predecessor, the structure will be used for teaching, research and testing in the high-voltage field. Incorporating a number of innovations, and designed for easy expansion, the laboratory will rank with the finest facilities of its type.

Research in Small Colleges*

By WARREN E. WILSON *President*, and R. H. COOK *Director of Faculty Research*
South Dakota School of Mines and Technology

I. Introduction

Why haven't we a research program? This is a question that has been, and is being asked by faculty members and administrators of many small colleges. These people see money, apparently poured into the large and great research schools; they see the romance of discovery, the favorable publicity that successful research brings. And these things appear to be good. They question their own failure to participate in today's great research effort. They are told on every hand that national survival, from both the military and economic points of view, demands answers that research alone can give. They have a sincere desire to provide some of these answers. Then too, the same unexplained urge to do research is felt by these men as by any active producer of scientific and technological knowledge.

Any question with as important a basis as that above deserves a carefully developed and honest answer. The purpose of the present paper is to impose suitable auxiliary or "boundary" conditions along with the initial question and then point out some of the most important factors which must be considered in the solution of the problem.

We shall begin by limiting the allusion of the words "research program" in the original question. They shall be considered to imply a program deliberately stimulated and promoted above and beyond that called for in the prosecution of *normal* graduate study. Faculty research which occurs spontaneously under *normal* academic circumstances shall not be considered a result of such a program. It appears reasonable to impose these auxiliary conditions in view of the fact that normal operation should already have received proper consideration and reasonable (if not always adequate) backing and support.

We shall discuss important factors under the broad headings of Research Requirements and Research Effects.

II. Research Requirements

A. Research Minded Staff: Space, time, basic equipment, a good library, and financial support are all essential to a research program. The single most important item, however, is a staff which includes a suitable number of influential, experienced research minded members. The word "suitable" should be applied in one or both of the following ways: (1) Suitable for the entire handling of the research program; (2) suitable as a nucleus to initiate research, inspire the participation of others and provide proper education in research techniques.

Either the small college has such men on its staff or it doesn't have them. In any case they are necessary. This point cannot be emphasized too strongly. The lack of such personnel immediately implies procurement of it. Researchers can be hired on a full time basis. Under the proper conditions they may be secured on a part time basis, or as lecturers, or consultants. Under long range planning, selected staff members may be given leaves

* Presented at the Annual Meeting, ASEE, Graduate Studies Division at the Univ. of Florida, June 24, 1953.

of absence for work in research centers. It may be that a well designed local effort can produce research skill and interest. In any event the method or combination of methods used must produce a research minded staff.

B. Time: Research also requires time. If the present staff is effectively handling a capacity load then that staff must be supplemented whether or not it is research minded. Sufficient additional staff must be obtained to account for the probable load imposed by research, graduate students sometimes are suitable staff supplements, but unless the service they give is greater than the service they require then nothing is gained from the standpoint of time. Usually there is a minimum number of graduate students that can produce a net gain in time. Frequently, in the small college, that number is too large for the equipment and space facilities available. This should illustrate that the problem of time demands careful manipulation. No effort has been made to exhaust the possibilities, in this connection.

C. Library: The small college library is seldom suitable for research. It usually lacks desirable abstracting periodicals, and quite often contains few of the publications in which research papers are printed. A survey of the literature, which may include basic textbooks as well as research papers, is a part of nearly every project. These materials should be easily accessible. Library policy should give the researcher freedom of the stacks, and should permit research periodicals to be checked out for reasonable periods of time. An issue of the *Reader's Digest* can probably be read between four in the afternoon and eight the next morning. An article in the *Physical Review* may take somewhat longer. Services, such as inter-library loans, and micro-film, are great conveniences if not real necessities. The library aspect of research is a basic one. Unless the small college is near an adequate library it will be necessary to provide the proper facilities.

D. Equipment: Equipment is commonly given the lion's share of consideration when research in the small college is discussed. Certainly, equipment is important but not in proportion to the conversation which it inspires. Basic equipment is a must. In any field the laboratory should be equipped to deal with the fundamental quantities, and reactions or processes. A great deal of good research has been done in biology departments which did not maintain a cage of monkeys. Very important results have been achieved in physics departments where not one single atom has ever been deliberately smashed. Much special equipment has to be built by the researcher whether in a large or a small organization. If a worthy project calls for a special, commercially available instrument or device that piece can usually be secured at little or no cost to the institution. We shall have more to say on this point in connection with financial support. Finally, while basic equipment is essential, equipment itself is not a basic issue.

E. Financial Support: Under every previously discussed issue money is implied. Research time means more staff, more staff means more money, and this money must be certain as it cannot be just a speculative possibility. Furthermore, a research staff cannot pull into its shell and stick its head out only for the purpose of announcing results. The researcher should converse with others in his own field, he should visit other groups, he should travel to meetings to present papers and hear other papers. Travel costs money and researchers are almost never overpaid. They will require substantial assistance for this purpose.

Library funds will need to be significantly larger with research than without. The additional expense will involve a periodic component since periodical publications will be purchased. It will involve a steady component to keep up with current books which previously were not deemed necessary. It may be that a rather considerable outlay of cash will be necessary to modify existing facilities and to

purchase micro-film and other new equipment.

Equipment costs can be limited to the purchase of basic instruments and devices which are not already available, and in good condition.

There are other items of expense too, but this paper is far too short to be exhaustive. One expense, which is significant, and which may be overlooked inadvertently is overhead. Heat, electricity, water, gas all cost money and still may almost hide themselves in normal operating expense.

One must remember that these are costs above normal operating expense. As such they represent additional financing problems. What techniques can be brought to bear to carry the added load? There are many; in this discussion only a few can be mentioned.

Many government agencies sponsor projects and give financial support on a project basis. Somewhat typical is the Office of Ordinance Research which will supply funds for worthy projects investigated by competent researchers. These funds can be used for materials, supplies, and expendable equipment (capital equipment too under some conditions). Faculty salaries, during intervals when the college does not pay, graduate student stipends, and wages for assistants can also be included. The OOR will also cover reasonable travel and overhead costs. This agency seems to be primarily interested in basic projects of high quality and of an unclassified nature. This and similar agencies, such as the National Science Foundation, and various branches of the Armed Forces are doing a tremendous job in the stimulation and promotion of research. Policies differ from one agency to another, and government red tape makes the processing of a proposal last from six months to more than a year.

Various privately endowed organizations also provide assistance for worthy research. A very appropriate example is the Research Corporation, which has as an avowed purpose the promotion of research in small colleges. The terms of the Research Corporation are similar to those of the OOR except that faculty remuneration cannot be included. Equipment purchased becomes the property of the institution.

Some of the scientific and engineering societies provide grants. These grants are well worth investigation although they are usually not large.

Endowments by an alumnus or a group of alumni appear to be successful in a number of schools.

Research institutes through which research may be sold as a service have been very successful in some schools and have been flat failures in others.

Again the discussion is not complete, it is meant merely to point the way.

III. Effects of Research

A research program can be good for a college or it can be bad. It can inspire the undergraduate, produce a better atmosphere for the post-graduate, make for a wide-awake faculty, and bring better equipment. Successful research will bring favorable publicity. Through research the small college can increase its service to the nation, the state, and to mankind.

But bad effects are also possible, and sometimes difficult to avoid. The research tail may ultimately wag the undergraduate dog; this has happened far too often. The result, to my knowledge, has never been good. Research can easily become the main criterion for faculty promotion and salary increases. This usually results in a split faculty with the two or more factions actively bucking each other. In this case the quality of teaching goes down, and surprisingly, so does research quality. A research program, once established, will never hesitate to buck the undergraduate program for money, facilities, and privileges, unless it is properly administered.

IV. Summary and Comments

Normal research activity in the small college is not discussed in this paper. By

normal we mean the graduate student research regularly done, and the occasional spontaneous project carried on by a faculty member. It is the writer's opinion, however, that both are desirable and that the latter should be encouraged and given every reasonable aid.

The desirability of the deliberately stimulated and promoted research program for the small college is not easily established. Many factors must be considered. Money is an obvious necessity and great care must be taken that the undergraduate program is not robbed to meet research costs. The very nature of the faculty must usually be modified. This modification unless carried out with wisdom can result in a split faculty and decreased effectiveness of both the normal and research operations.

It is the opinion of the writer that wise administration can effectively eliminate the dangers of a research program to the small college, and that the great good from such a program far outweighs the work and effort required.

College Notes

During the Spring quarter of 1954 (March 24 to June 4) the Institute of Statistics of the **University of North Carolina** will sponsor a special program of course work, lectures and seminars on statistics for research engineers, physicists and chemists. The primary objective of this program is to provide an opportunity for industrial research workers to acquire a working knowledge of modern statistical concepts and techniques. Emphasis will be on the efficient design of experiments and the analysis of data therefrom. Informal seminars on statistical problems submitted by the participating students will be held. Guest lecturers will include Dr. W. J. Youden and Dr. M. G. Kendall. Regular college credit will be granted for course work satisfactorily completed. For further information write to Institute of Statistics, North Carolina State College, Box 5457, Raleigh, N. C.

* * *

The formation of an Engineering Research Institute at **Tulane University**, to serve the needs of the expanding industry of this area, has been announced by Dr. Rufus C. Harris, president of Tulane. Dr. Harris said the institute would contract with industrial firms for specific research projects involving practical problems in numerous fields of engineering science. About 20 faculty members of the school of engineering will take part in the work of the institute, he added, with physicists, chemists and other specialists from various divisions of the university available as consultants on the projects.

*Selected Reports by Institutional Committees on Evaluation of Engineering Education

Foreword

The Committee on Evaluation of Engineering Education, with Dean E. L. Grinter as its chairman, was appointed by President S. C. Hollister in the spring of 1952 to study the impact of expanding scientific developments on engineering education and ways of improving current engineering curricula. It was felt that all engineering educators would take an interest in and could contribute to the discussion. Hence, the Committee discussions were referred to similar Institutional Committees for comment. This "grass-roots" approach led to the development of almost sixty Institutional reports encompassing penetrating analyses of the problem. These reports were of invaluable assistance to the Committee during September, 1953, when the Preliminary Report was drafted. Many suggestions made by the Institutional Committees were incorporated therein. This Preliminary Report, and Summaries of the Institutional Reports representing a perspective of the nation-wide thinking on this subject, were mailed to all engineering colleges on October 14th for further comment and study.

Since no two individuals could brief this wealth of material in the Institutional Reports with identical results it seemed advisable to select several of these for publication in the Journal in abstract form. The seven which follow were chosen because of their unusual analysis and recommendations. This does not imply that the others were not excellent also. Many of them were, but most of these were of such form that they could be summarized as a group. It is regrettable that space does not permit publication of more of these in the Journal. They can, however, be obtained on loan by request.

On behalf of the Committee I wish to take this opportunity of thanking all Institutional Committees and especially those whose reports are published here for their splendid cooperation.

The Committee's task is not yet finished. It is hoped that all engineering educators will have an opportunity of studying the Preliminary Report and Summaries just released, and of discussing their views on this most important subject of Evaluation with their own Institutional Committee before its final report is submitted in early December.

D. H. PLETTA, *Secretary,*
Committee on Evaluation of
Engineering Education

*A summary of the Preliminary Report of the ASEE Committee on Evaluation of Engineering Education was published in the November issue of the JOURNAL OF ENGINEERING EDUCATION.

Abstract Report of the Stanford University Committee on Evaluation of Engineering Education

Being in favor of improvement of engineering education is somewhat like being, with Calvin Coolidge's preacher, against sin. In both cases there is a great temptation to assume that since the agreement is so universal the improvement may be achieved, or the sin eradicated, by showing educators how to teach better or sinners how to avoid sin. This report seeks to avoid this temptation and to search for the basic problems and conflicts which must be identified and solved to effect significant improvement.

1. *Identification of the Engineering Educational Enterprise.* A clear statement of the aims of the engineering education enterprise and some agreement regarding them must precede intelligent discussion of means for improvement. First, it seems wise to attempt to obtain a clear picture of just what it is that engineers do which we wish to educate for.

By and large engineers are paid by society to work on systems dealing with problems whose solutions are of interest to that society. These systems seem to group conveniently into (a) systems for material handling, including transformation of, transfer of, and conservation of raw and processed materials; (b) systems for energy handling, including its transformation, transmission, and control; and (c) systems for data or information handling, involving its collection, transmission, and processing.

In carrying out this work engineers engage in various activities ranging through engineering research, design and development, construction, operation, and management. Within the confines of one or more of these activities the work of an individual engineer is likely to be determined more by the nature of the overall engineering problem with which he is involved than by the particular branch of engineering in which he received his undergraduate training.

The essential unity of engineering endeavor is also emphasized by the extent of the fundamental background required by all engineers in their work. Included in this are knowledge of (a) economic, sociological, physiological, and psychological principles of human behavior; (b) physical principles underlying macroscopic phenomena (consisting of Newton's Laws, the Conservation of Mass, Energy, and Atoms, the State Formulation Principle, the Second Law of Thermodynamics, Maxwell's Electromagnetic Field Equations, the Electric Force-Charge Relation, and the various rate equations); and (c) mathematical logic and the art of engineering design or synthesis.

2. *The Engineer's Place in Society.* If this identification is reasonably accurate, an engineer is a person trained to undertake technical problems of the types listed above. But an engineer, as a professional man in society, is much more than this. The engineering profession is a relatively young segment of our society—as recently as a century ago engineering training was deemed unfit for collegiate instruction. But within the past few decades scientists and engineers have become an extremely influential group in society, wielding a tremendous decision-making power.

In the history of our country there have been many such groups which have exercised powerful control in society. The power of the clergy and of the landed aristocracy has waned; that of the legal and business groups is still felt. In recent years the labor and scientist-engineer groups have been in the ascendancy. With power come important social and moral responsibilities; education for these responsibilities is essential.

The real challenge to the engineering profession today is not in the field of technology. Technologically we have progressed to the point where we may have, if we desire, an impenetrable ring of

radar-fired homing rockets along the Arctic circle, or a six-lane superhighway across the Bering Sea; a guided missile capable of devastating hundreds of square miles, or a food production and distribution system which will insure that no individual anywhere in the world need ever starve to death. The real question is not whether the job can be done—given enough money and people any of these things can be accomplished. The important questions to be answered are of the type, "Given a limited amount of effort and money available, what should be done?"

3. *Education in the Larger Sense.* Those making these decisions involving value judgments must have not only technological understanding, but a broad educational base and maturity. Though these cannot be insured by the fact of four years in college, the college must provide the initial momentum, especially by challenging gifted students to prepare for this future intellectual leadership.

Sir Richard Livingstone speaking at the M.I.T. mid-century convocation in Boston suggested the following formulation of five components of an education: (a) The educated man should have learned to distinguish between searching knowledge of a subject and mere interest in it; thus he has specialized in one area of knowledge for intellectual as well as economic reasons. (b) He should have met man in literature and history and have a sense of the great human values. (c) He should have an awareness of the social and political problems of the day, and of the power and importance of science and technology in modern civilization. (d) He should view his times with historical perspective. (e) He should know the rudiments of the science of good and evil.

It is fairly generally agreed that engineering schools do a reasonably good job of helping their students furnish themselves with the first of these components. With present-day demands on engineers, both for highly specialized knowledge and for broad technical competence in the general techniques of engineering analysis and synthesis, the undergraduate period has become largely pre-professional education. To make the most effective use of this period we must look upon it as merely *the first four years of the education period,* to which will be added the experience of apprenticeship in industry or government and, for an increasingly large proportion, additional formal education.

It is not possible for engineering educators, however, to delegate all responsibility for the accomplishment of the last four of Livingstone's objectives to the church, the home, and the teachers of "humanities" courses and concentrate solely on imparting the first component. Because engineering education is a part of the overall educational enterprise they must assume some responsibility for the success of the overall enterprise, above and beyond the responsibility for the success of their own portion.

4. *The Key Factors.* On the basis of these arguments we may define the proper task of engineering education. Starting from the student with his consuming interest in diesel engines or electronic circuits, it is to carefully lead him to an awareness of his need for, first, a sound theoretical training in basic science, mathematics, and engineering techniques, and second (because this requires more maturity), the development of wisdom through broad experience outside his professional field.

Accomplishment of this task will require good teachers, in quantity. But the more we look into the problem the more one fact seems to stand out clearly—*there are only two important factors in the educational process, the student and the teacher.* The rest—curriculum, administration, structure—are unimportant except as they influence the effectiveness of student or teacher.

The raw material, the student, is to considerable extent out of our control—the second factor is the one we must work with. *We shall have improved education of engineers only when we have more good*

engineering teachers working in an environment in which they can function effectively.

We sometimes forget this important truth in our preoccupation with curriculum and programs. No student was ever taught by a curriculum. Any program is no better than its teacher. On the other hand, a good teacher accomplishes his work within any curricular framework without being unduly hampered.

5. *The Nature of the Problem.* If these arguments are not based upon faulty premises the paramount problem of engineering education (and, of course, of education in general) is twofold. The first part is to educate and induce into the teaching profession a sufficient number of that kind of teacher whose individual impact on the student can accomplish what no curriculum in itself can do. Secondly, these teachers must be provided with an environment in which they can function with maximum effectiveness.

A great deal can be accomplished toward these ends by engineering teachers and administrators. On the other hand, the historical record indicates that really profound changes will depend upon factors outside the university. For, in the final analysis, the trend of engineering education is strongly influenced by long-range social forces. The attitude of society determined to a large extent whether any activity will flourish or decline.

Research is a case in point. In Germany during the first half of the last century research flourished because its future importance had been sensed by the people and leaders of that country. In this country and Great Britain there was no such support, and research activity languished. Later, when it was apparent that leadership in research was an important source of German power, the attitude of society shifted. Philanthropists endowed great research projects, government and industry began to build up research organizations. In the space of a generation empirical research leapt from the position of seeking support to that of the most highly-honored activity in the university.

Thus if education in the larger sense, as defined earlier, is to flourish, this must come about because society has come to hold that education in esteem and to actively support it. Financial support, while important, is simply a tangible indication of moral support. If it should become apparent that industry, government, and society in general value the wisdom and perspective of the broadly educated man above vocational or professional training (as society in this country once did) then we would find our engineering students and professors integrating their technical knowledge with studies of history, philosophy, and literature. So long as the scale of values remains with specialized professional training ranking near the top, there are imposed rather rigid restrictions as to what changes can be made within the universities.

Our view of the problem of engineering education effectiveness must be, like the education we wish to produce, broad and searching. By examining the position of the engineer in society and the tools he needs to fulfill this position successfully we can come to some conclusions as to what our aims should be. To see whether these aims are likely to be accomplished it is important to note whether they conflict with the attitudes of society. In this way we can concentrate on the aims which can be realized by efforts within the university or, if we choose to pursue programs whose success would require a shift in the attitude of society we can at least recognize the magnitude of the undertaking.

J. B. Franzini
W. G. Ireson
S. J. Kline
W. W. Harmon, *Chairman*

University of California, Los Angeles Committee Report on Evaluation of Engineering Education

Introduction

"Probably the most significant single characteristic of the engineering educational field is that it has no generally accepted professional objective as a goal for the educational program."

The two main long range goals of this study are: (a) to provide a basis for the coherent development of engineering education in the United States and Canada adequate to serve the needs of the ever-present future, and (b) to develop a measure of the existence and adequacy of such engineering education. To achieve these long range goals, the problem of engineering education must be examined in its broadest social and professional setting unrestricted to the college program per se. Consideration of such setting leads the committee to propose that the differentiating characteristic of engineering education lies in its motivation and methodology. This the committee amplifies via the following terse statements.

Nature of Engineering

The subject matter of Engineering has at all times been fundamentally rooted in the physical sciences with a varying and generally increasing emphasis upon the biological sciences. The ever-receding boundaries of the engineering system make difficult the characterization of engineering purely on the basis of subject matter.

In the recent past concerted efforts have been made to evolve the distinguishing characteristic of engineering. Receiving the most attention has been the term "design." Some persons imply that design includes the functions of explanation, prediction, and evaluation. Design also carries with it the implied query "of what?", and the answer generally has been "engineering works." These include structures, circuits, machines and processes of scope sufficient to meet the demands of mass production. The profession, in focusing on "ability to design" engineering works, has clarified a distinguishing characteristic of engineering.

Interrogation of nature must be unceasing and engineering action cannot await a complete reply. A full reply constitutes formulated knowledge or science, and this often comes via unformulated knowledge or empiricism. Engineering deals wholly neither with formulated nor unformulated knowledge, and the unformulated portion must be in transition toward formulation. Pure science and expert craftmanship are thus at the boundaries of engineering.

Historically, the outcomes of engineering activity have been rather immediate combinations of readily available materials and obvious forces of nature—and these have resulted largely from strict ingenuity and experience. The "putting-together" of today and tomorrow—a synthesis—involves a measure of abstraction not heretofore present. But in functioning in the design role illuminated above, the engineer, no matter how abstract the problem, employs a definite putting-together methodology. Thus, the essence of engineering is and will be the methodology of design.

Definition of Engineering

"Engineering consists of creative, comprehensive thought and resourceful, effective action directed—through the methodology of design—toward the evolution, evaluation and accomplishment of socio-technological objectives, and means thereto within a physical environment."

This clearly identifies engineering as the agent and advocate of society with physical nature, and also makes clear an essential essence in the execution of the tasks, i.e. through design. Methodology of Design consists of:

(a) the exercise of tolerance, rational method and the discriminatory use of both science and empiricism pertaining to the whole problem;
(b) the understanding of significant properties and behaviors of several physical environments;
(c) the functions of explanation, prediction and synthesis relative to production, distribution, control and utilization of the energy, material and information of nature as supplemented by the resources of men, and
(d) formulation and use of technical, economic and social criteria for effecting decisions leading to optimum outcomes in a framework of constraints.

Nature of Engineering Education

"Education is the process by which man evolves. It includes all experience, all learning, all growth, all development. In itself it is neither good nor bad. . . ." Engineering Education refers to the process by which the Engineering Aspirant becomes a Professional Engineer.

The term "Engineering Education" will, for the sake of ease of reference refer primarily to the college program. However, its function and nature must be definitely determined by the subsequent industrial training.

Engineering Educational Program

An engineering program becomes optimum preparation for industrial training when (in part) it provides a realistic proportion of the basic constituents of design: science, language (including mathematics), experimentation and application, and methodology (including philosophy, problem solving and integration of knowledge). Such is certainly not true of usual programs in college science, mathematics, or applied (industrial) arts departments. "Applied" physics and "applied" mathematics are potentially confusible with "engineering" physics and "engineering" mathematics. Similarities and/or differences may be traceable only to the motivation and examples of both students and staff. In a very real sense, it appears that the (pure) science or mathematics content of an engineering program has an upper bound rooted in basic motivation! This helps undergird the proposition that the engineering program is distinguishable by its mixture and approach.

Professional society gatherings, field trips, cooperative work-study programs and campus cultural activities engender professional attitude and enrichment of personal experiences. Such cocurricular activity is a recognized part of an engineering college program although it requires much exploitation to better meet the demands of the future.

One basic attitude of particular significance to engineering is non-authoritarianism. The product of teaching so directed is a thinking, creative student who so appreciates where knowledge comes from that he knows how to go about knowing new things. Education provides frames of reference which gives meaning to experience.

Core Disciplines for Optimizing Preparation

"The purpose of the four years spent in college is not to teach students what to think, but how to think and how to learn from experience. . . . (Furthermore) industry looks for men who have the ability to get things done."

A significant function of Engineering Education is selection of those qualified on the basis of personal as well as mental traits, and their motivation to become engineers. The caption of "Core Disciplines" perhaps implies a certain level of rigor which, of itself, will fulfill a selection function. In the overall engineering college program, consideration should be given to opportunity for relaxation and contemplation, cooperative work-study experiences and co-curricular activities.

Conclusion

Accreditation is concerned with "approval" of certain educational programs meeting certain minimum requirements.

Such approval has been accepted by society, as a whole, as an indication of minimum standards of performance or competencies relative to the practice of engineering. It serves as a partial basis for legal and professional recognition of engineers and at the same time helps safeguard the safety and "welfare" of the public; the latter is undoubtedly a necessary function to be performed in our society.

An attitude of intelligent daring and experimentation—rather than conformity—is both the safeguard of and the springboard into the future. The colleges and industry should help the ECPD formulate "the minimum" and together they must go "the second mile." Moreover, this cooperative self-evaluation must never cease, and, to this end, the philosophy of the whole accreditation program should include the concept of continual review.

J. C. HARPER
J. W. MCCUTCHAN
C. L. SONNENSCHEIN
D. L. TRAUTMAN
L. L. GRANDI, *Chairman*

Evaluation of Engineering Education Reported by The Institutional Committee at Cornell University

The committee's approach to this study has been through critical consideration of the kinds of work our engineering graduates will be doing in the years to come and the problems and responsibilities they must meet. It was agreed that engineering students must be trained to do competent professional work in their first positions for without such preparation they may not have opportunity for promotion to greater responsibilities. However, mere preparation for the first job is not enough. Our training must also provide the basis for advancement. The better the young engineer's future duties and responsibilities can be anticipated, the more clearly can our training objectives be defined. This, in turn, should be the basis for modification and improvement of curricula.

It was recognized that training in specific fields of engineering will lead to differences in the kinds of work and responsibilities for our engineers. These differences must be considered in assessing the adequacy of curricula. There is, of course, some preparation basic and common to all curricula in engineering. Every engineer should have adequate preparation in mathematics and in physics and chemistry and the other sciences on which his technical work is based and in mechanics, thermodynamics, materials of construction and the other commonly fundamental applied sciences. Every engineer should be able to write and speak correct and effective English; he should have some knowledge of the history of the civilization in which he lives and of the impact of his professional work on that civilization. He should be prepared to deal effectively with the economic and social problems that arise in connection with his professional work. Beyond this common basis, the curriculum in each specific field of engineering should be formulated to prepare the graduates for effective professional work, and with regard to probable ultimate as well as immediate nature of that work.

Engineering Trends

To an increasing extent research and development divisions in industry are being filled with men with engineering training. This trend is due in part to the recognition that a man with engineering background is well qualified to do research, and in part to the use of the development division as a training school from which men may be drawn to fill

positions in supervision and management.

Within the past few years, engineers have been employed in increasing numbers in other than strictly technical capacities and have advanced more and more frequently to the top positions in management. It is reasonable to assume that this trend toward the use of men with engineering training for work that is not purely technical will continue and increase.

In the future, it is expected that industry will place greater emphasis on the research and development effort. It seems likely that industry's concept of research and development will broaden so that it guides and stimulates all phases of company operations including sales, distribution, product quality and raw materials as well as manufacturing. The role of the engineer includes participation in research and development in some cases, but also covers the guidance of research programs and policies and the utilization of research results. Whether the young engineer's assignments are in research and development, engineering, plant operations, purchasing, sales or any other division, his problems are technical. The effective solution of these problems requires the use of technology intimately mixed with economics and human relations. Professional advancement to supervisory, administrative and management positions comes after he has performed well in technical jobs. It is believed that research and development will be a major stepping-stone from which future engineers will proceed to more responsible and diverse situations. This trend appears to be less significant in civil engineering. In all fields, it is believed that the trends toward greater diversity in the kinds of work and more rapid advancement to managerial and supervisory positions will continue and become more pronounced.

Another trend which will have an important effect upon engineering education is the technical institute movement. In the last ten years, many such institutes have been started throughout the United States and are proving that they can train adequately for many of the minor jobs which previously had been filled with engineering graduates. This movement will tend to confine the outlet for engineering graduates to the professional phases of engineering which in turn means that engineering colleges will have to provide the broad and deep training necessary for professional leadership.

Training Requirements

With the rapidly increasing extent of our knowledge of science and engineering and the increasing breadth of training required for effective professional work in engineering, the graduating engineer must know about more kinds of things than was required or even possible a few years ago. We cannot expect to crowd all of this necessary training into the already full curricula unless we make room for it by increasing the effectiveness of instruction in the existing courses.

This does not mean that the training in the present basic and essential subject should be made more superficial; it does mean that our existing courses should be re-examined critically to eliminate non-essentials and to be sure that important topics are covered clearly. We should review our teaching methods to insure that the time spent in the classroom and the laboratory is used as efficiently as possible, and to eliminate needless duplication and unproductive effort on the part of both the staff of instruction and the student body. Many of the courses in our universities are taught in about the same manner today as they were taught thirty years ago. Perhaps this is the best way, but we should not assume that no improvement in the course content or the method of instruction is possible until we have made a critical study of both scope and method.

It is possible that we take too seriously the mere mechanics of curriculum carpentering and that if we concentrated more on the broad nature of the training and less on the titles and credit hours of

the several courses, we could provide better preparation with less unproductive effort on the part of the student. We should expect that any capable man will continue to intensify and broaden his education after he leaves the university; we should realize that all that the university can do is to provide the foundation for the real education that should continue throughout his later professional life.

In general, then, those of us who are charged with the responsibility of training engineers for successful professional work in the years to come should ask ourselves:

1. Do our present training programs give adequate training to enable the graduate to do satisfactory work in his chosen profession?
2. Do the present curricula include work not of sufficient value to justify their retention?
3. Do they provide him with a foundation on which to build his later training by experience and study for positions of higher responsibility?
4. Can we, by critical study of course content or methods of instruction, improve the effectiveness of our teaching, even if such improvements require complete revamping of our present courses?

To accomplish our aims students need more practice not only in solving problems, but in formulating them. They must learn in school how to apply what they know to new situations and they must be encouraged to follow advances in technology and to make these new developments part of their working knowledge. As teachers we must assume responsibility for personal and professional development in addition to the training we give in the fundamentals. All this suggests some changes in curricula, but it does not necessarily mean crowding in more courses. Much additional learning can be introduced through the courses we already have. What we do need is more effective teaching.

Objectives of Different Curricula

Engineering education cannot, however, be confined to the study of basic principles. The ways in which engineers use fundamentals in their profession vary so greatly between the different branches that some emphasis and training must be directed toward specific applications in each field. Facility in applying fundamentals requires practice and experience in their use. In each branch there are unit operations and processes, techniques and types of equipment common to whole groups of industries which may serve to illustrate application of principles. Differences in type of employment, field of activity, and kind of work lead to different training objectives and different curricula in the several divisions of engineering.

C. R. Burrows
N. H. Bryant
N. A. Christensen
G. P. Fischer
D. F. Gunder
P. L. Hartman
H. J. Loberg
C. O. Mackey
F. H. Rhodes
J. E. Hedrick, *Chairman*

Abstract Report of the Johns Hopkins University Institutional Committee on Evaluation of Engineering Education

The problems currently facing the field of engineering education are the result of our present attempts to teach the bases and facts of an enormously expanded science and technology in the same number of school years considered to be adequate half a century ago. There is more for today's engineering students to learn than there was years ago. The universities and colleges are being pushed from another

side as well. Today for example it is uncommon for the college freshman to meet the calculus. Courses in algebra and trigonometry are common in this first year, with the result that those courses requiring a knowledge of the calculus as prerequisite must, in most cases, wait until the third year. Furthermore, in the vast majority of cases the colleges are forced to take the major role in developing a command of the English language and a modicum of self expression in the student.

This is the problem: An expanding science and technology to be crammed into a period of time which must be limited by the economic and social pressures on any student; a need for increased attention to the formative freshman and sophomore years; and, with all this, a need for a recognition of the necessity of the various social and sociological phases of university education and their importance to the individual and his place in our society.

One solution to this problem becomes apparent after close scrutiny of the demands and hiring techniques of industry. Industry needs and hires men for two distinctly different levels of engineering work. The first level is a purely operative level, the second, or "scientific" level, is a level at which the research, planning, and decision making is carried out. With the increasing complexity of modern industrial operations, the degree of educational background required for this second level of activity is increasing yearly, whereas the requirements for the former have remained almost static.

Split Curriculum

It seems to the members of the Hopkins Institutional Committee, therefore, that engineering education might best proceed toward the development of a split curriculum. As an example of the manner in which this type of curriculum might function, the following is proposed.

The first two years of engineering education might well be the same for both curricula. The "scientific" curriculum would then offer courses of a very fundamental nature and of a type emphasizing the interrelationships between the fundamental theorems of basic science and applied engineering. It is felt that this course could not be completed in the normal four years of undergraduate training but must, necessarily, extend into those portions of the present curricula now normally reserved for graduate studies.

Those persons judged best suited for the operational level would initiate (following the two years of basic liberal arts and science training) two additional years of training leading to the baccalaureate degree, to be considered, for them, to be terminal. These two additional years would emphasize the practical or applied phases and would pass lightly over the theoretical.

The committee faces the fact that this plan presents certain problems. These might be divided into two categories, namely problems of a psychological nature and problems of a purely administrative type. Considering the first of these, it must be obvious to all that there is no stigma attached to either of the proposed curricula. Provision must be made for reevaluation of a person's interests and abilities such that it is possible to change from one program to the other. Administrative problems would be those revolving around such questions as: (1) What should be the subject matter and subject emphasis for each type of curriculum? (2) Should there be separate institutions specializing in each type, or should each institution attempt to do both jobs?

Subjects for Discussion

The following subjects are proposed for future discussion of this committee. It is felt that the crystallization of ideas on each of these topics will materially benefit this evaluation program.

(1) To what extent should engineering education broaden its attention to the field of "Expanding Fundamental Sciences"? Should more introductory-type courses in diverse new fields be introduced or should

more searching and minute attention be directed toward developments in a special field?

(2) What is the nature of the job the colleges and universities are *supposed* to do in preparing and training engineers for industrial positions, this from the point of view of the industries doing the hiring?

(3) What is the most advantageous distribution of humanities-type courses in both curricula? Parallel to this is the problem of the distribution of the basic sciences.

(4) Some attention must be directed at the problems involved in teaching mathematics to engineering students in both portions of this split curriculum. In particular the merit of the "pure" approach vs. the "applied" approach must be examined.

The Hopkins Institutional Committee has thus far devoted a major portion of its discussion to the desirability of and the problems involved in the idea of the split curriculum. The members of this committee are not unanimous in their thinking on all phases of this idea. It seems, however, to be the consensus that it is basically a good idea but one to which much further thought must be devoted.

W. C. BOYER
D. H. FAX
T. LARSEN
R. T. STATON
H. E. HOELSCHER, *Chairman*

Abstract Report of the McGill University Committee on Evaluation of Engineering Education

A gradual change in engineering education during the next quarter-century can be anticipated, chiefly on account of advances in technology and wider diversity of applications of science. The widening field will compel a more fundamental and a more generalized treatment of subject matter, because individual treatment will no longer be practicable in the usual span of the course. Adequate coverage will be possible only by permitting a greater degree of penetration of fundamental physics, chemistry, thermodynamics and geology, into the courses, and by unification of courses and fragments of courses, together with emphasis on those things which are least likely to change. The content of existing courses will undergo changes parallel with the evolution of practices. Engineering teaching will become less specialized but without dropping any of the present main divisions. Lectures will have to deal with less practical aspects and more with basic principles. The demands of time will force a more extensive use of demonstrations and visual aids wherever possible in place of laborious testing experiments.

The training of engineers will have to take increasing notice of their position and influence in society and their recognized adaptability for administrative and managerial positions. A greater content of the life subjects, including psychology, will be desirable in engineering courses. This trend will necessitate a broadening of curriculum along non-technical lines, with lessened emphasis on purely technical aspects. A searching examination will have to be made of all courses to find the time in which to offer these subjects, if the length of the course is not to be extended. The desirability of broadening the curriculum along these lines seems to be favored by most engineers. A wider selection of options may be the answer in some cases, but a too-wide scale of options in the undergraduate years leads to undesirable specialization. In the undergraduate years, the probable trend will be towards strengthening the basic engineering training. Some specialization will re-

main but will enter at a later stage than is the case at present.

Collaboration with Industry

There will be an increasing trend in industries to train graduates in their particular technology and specialized professional work, and this will enable more general and more thorough treatment of basic subject matter at the university. It is probable that collaboration with industry will be greatly increased, and this may lead to an extension of the practice school and cooperative course ideas. Teachers will find need for wider industrial experience to keep up with changes in technology.

The development of the engineer capable of understanding all aspects of a whole project, and its direction, will be a major problem in engineering education in the coming years. In the planning of curricula, authorities must never lose sight of the degree of maturity, mental outlook, and personality, of the young engineering student.

J. B. PHILLIPS, *Chairman*

Abstract Report of the Oregon State College Institutional Committee on Evaluation of Engineering Education

Answers to questions prepared by ad hoc sub committee

1) *What trends in development and/or exhaustion of our natural resources appear likely to affect engineering practices in the next 25 years?*

The rise of nationalistic feelings and industrial development in heretofore undeveloped foreign nations will tend to make us more dependent upon our own reduced resources. Population pressure and maintenance of the living standard will demand the conservation and efficient utilization of all our natural resources. Increased production costs and depletion of high grade reserves of many of our resources will make necessary the economic development of low grade reserves and in some cases the substitution of materials. Some of these possibilities are outlined below:

a) *Petroleum.* Our national petroleum reserves in the continental limit of the United States are becoming smaller in time of years supply available to satisfy our needs. Higher labor costs and deeper wells are making petroleum products more expensive. The continuation of this trend will restrict the use of petroleum products as fuel since they will be needed in the manufacture of more expensive and valuable chemicals.

b) *Metals.* The end of high grade iron ore deposits in this country and the resultant increase in the cost of producing steel will result in the wider use of aluminum and magnesium as structural materials in all fields of engineering. Copper and lead will also have to be replaced in many of their present applications.

c) *Water.* Continued growth of population and depletion of the ground water reserve will force intelligent planning on a regional or national level for the efficient use of our water resources. The increased cost of domestic water because of longer conduits or more expensive treatment may make the purification of sea water feasible. The mineral content of sea water may be a valuable by-product.

2) *What recent developments of familiar materials and introduction of new materials appear likely to modify engineering science and practice in the next 25 years?*

The use of light weight aggregates and prestressed steel for structural concrete

and the substitution of other materials for steel will force revision of building codes and shop practices with more emphasis on engineering the individual project. Recent development in new alloys for magnetic materials and research in the field of dielectrics will change the design and production of electrical equipment.

Materials which can withstand high temperatures and also have high strength are needed in many fields. Because of their resistance to high temperature ceramics may offer possibilities.

3) *What seems likely in the development of power sources in the next 25 years?*

4) *What developments in fuels (for example, the metals) are likely to modify power production in the next 25 years?*

The current trend of more horsepower per person will be accelerated by the depletion of our natural resources quoted above. This will necessitate the ultimate and efficient development of hydro-electric sites in all parts of the country. A nationwide pooling of all generating facilities would contribute to the overall efficiency.

Atomic energy is in the process of development for both stationary and mobile units. Successful development of this source will depend upon an adequate supply of raw materials, economical methods of preparation and protection of personnel against radioactivity in large and small units.

The relatively large reserves of coal and shale oil may be used in gas turbines or jet engines to replace petroleum products as a fuel for prime movers. Gasification of coal in place with power development at the mine is a possibility.

Other possibilities in power development are (1) solar energy, (2) power from the wind, (3) direct conversion from fuel to electricity.

5) *What developments in the art and science of automatic control will be significant in the next 25 years?*

In order to get a more uniform product and reduce human effort, automatic control will continue to spread through industry. The flexibility of control equipment will be increased with the introduction of electronic computers which may dictate changes in control with changes in conditions. The use of automatic control (with computers) to operate power system or the traffic control system for a city are illustrations of the possiblities.

6) *What in the life sciences (including psychology) are likely to be important in engineering in the next 25 years?*

Continued research in the life sciences may permit development of a quantitative treatment of these sciences through some branch of mathematics, and thus give information to the engineer in usable form. In other words, quantitative treatment may give the engineer sufficient tools to evaluate the effect of his works upon society. Problems which will face the life scientist and have significance for the engineer are: (1) the effect of automation if carried to the extent possible; (2) recognition of unnecessary and avoidable hazards in current living and demands for minimizing these hazards; (3) dispersion of the population; (4) higher average age of the population; (5) necessity for planning resource development on a national level.

7) *What changes will occur in engineering practice during the next 25 years?*

The increased cost of labor and materials will make careful engineering design economically feasible and will encourage research and development. On the other hand, the use of electronic computers even in small engineering offices should reduce the time required for routine computations. Simplified drafting practices may further reduce the engineering time spent in a routine manner.

With reduced time spent on routine and the means at hand to solve complex problems economically more engineering time will be spent in the collection and analysis of data for the individual design. The practicing engineer will have to be more familiar with mathematical analysis and

will need a more complete understanding of economic and social trends than he now has.

8) *In your opinion how will engineering education 25 years from now contrast with present engineering education?*

The growth of Big Industry in the last half century suggests that it will in the future wish to train the young engineer in a specialty; and since more graduates will find employment in such situations rather than in small businesses, the bulk of the demand will be for men with a general, rather than specialized, training. This would indicate a shift in engineering education toward the unification of the individual curriculums such as Civil, Electrical, Mechanical, and Chemical Engineering into a unified course which might be called "Engineering." Further development along these lines may lead to unification of Chemistry, Physics, Mathematics, and Engineering into a course called "Science."

The general training which the engineering graduate will receive will be on a higher scientific level with a much greater emphasis on mathematics, physics, and the applications of physics which cut across all the present branches of engineering. Design procedures and industrial "know-how" will be de-emphasized.

The continuation of the current trend will concentrate the bulk of research and development of basic and applied science with industry rather than the colleges and universities. The graduate work in engineering will be concerned with a "professional" curriculum of perhaps two or three years to offer specialization to those men who wish to go into consulting work or engineering teaching.

Engineering faculties of the future will be expected to teach at a higher scientific level with more emphasis on theory and less emphasis on practice.

A. D. HUGHES
W. H. MARTIN
R. L. RICHARDSON
L. N. STONE
C. E. THOMAS
J. S. WALTON
L. A. CLAYTON, *Chairman*

Abstract Report of the Illinois Institute of Technology Committee on Evaluation of Engineering Education

Introduction

Studies of the Illinois Institute of Technology Committee were limited to: a) basic principles, b) creative thinking, c) research, and d) professional development. Before discussing these items some problems peculiar to engineering education are outlined briefly. The subjects listed then are presented in the order named.

Problems

The four principle phases of a well-rounded engineering education involve training in: a) communication skills, b) science, c) planning and design, and d) professional or social development. Communication skills include English, mathematics, drawing, surveying-mapping, and other related subjects. Proficiency in these areas makes possible most effective use of knowledge acquired in other phases of engineering education. Although technology in the past often preceded science, full development of any modern engineering undertaken can be realized only by the application of scientific principles. Whereas the scientist is interested in determining what will happen if certain elements are combined, the engineer is interested in determining what elements must be combined to perform a specific function satisfactorily. Planning and design are the syntheses of facts and desires

often conflicting, through the application of scientific methods. The modern engineer plans, designs, builds and maintains projects and services which affect the lives of everyone. To be of maximum value to society, he must have an understanding of his duties, his opportunities and his moral and spiritual obligations to that society. The foundations for such understanding, of course, are established long before the engineering student reaches college, but these teachings must be augmented through his formal education.

It is not difficult to establish goals. The real problems arise in connection with: a) obtaining the personnel qualified to teach adequately the subjects and overall philosophy of the profession, b) determining the proper combination of subjects to teach, c) integrating each curriculum so that each part supplements the other parts, d) developing the confidence and enthusiasm of students to progress beyond minimum requirements, and e) selecting and using methods of measuring competence. Also there are the problems of minimizing such factors as a) inadequate physical facilities, and b) interference with the educational program caused by requirements of military services and other activities. These items of course do not exhaust the list of problems faced by engineering education but they highlight some of the important ones.

Basic Principles

What principles of what subjects should be included in the undergraduate curriculum of an engineering college? A thoroughly integrated program would limit the number of principles taught to those which would be used in later courses. Actually these probably would be the only ones retained by the student anyway. Mastery of a limited number of essential laws would be far better than a superficial knowledge of expanded subject matter. Creative thinking, so essential in professional work can result only after basic laws are mastered.

Creative Thinking

Creative thinking is a characteristic of professional engineering. First, however, students who have the requisite aptitude must be selected. Special abilities are necessary for mastery of tool subjects, e.g., mathematics and physical sciences. High general intelligence is required to utilize acquired information in practical situations. College entrance tests are reasonably good tools for selecting the student whose general ability is equal to college work. One direct way for engineering schools to improve quality of graduates is to devise tests which specifically evaluate aptitude for engineering. A program of this kind could be undertaken at once with data already accumulated.

The first step in creative thinking is the definition of the problem. The student can be helped to learn to think creatively if the importance of defining his problem clearly is emphasized. The next step is examination of available information which can be utilized. The final step is organization of information in a way to effect a solution or to define the area in which additional information is necessary. This is the process by which advances are made in all fields of science, pure and applied. The engineering student should be taught this process and should be given extensive practice in applications to real and hypothetical problems. After two years about 25 per cent of factual material is retained, but the method of attacking a problem and the technique of transferring pertinent information persist once they are acquired. Research is one activity which helps to develop creative thinking.

Research

The philosophy of expanding science is considered to mean the principle of complete freedom to follow interesting paths of investigation wherever they may lead. The application of this philosophy yields fundamental research and is therefore the essence of advances in basic science. The engineering student should be made to

realize that the continued application of this philosophy is imperative because results from fundamental research today are the foundations for practical developments tomorrow. Thus the future of the engineering profession is closely related to discoveries made first as a result of fundamental research in pure science. Many large corporations are keenly aware of the importance of fundamental research and dedicate a significant percentage of their research budgets to such activities. Young engineers should be made aware of such programs and of the importance of expanding them. Consideration should be given to including in the first year a course or series of lectures to introduce the students to this relationship between fundamental research and engineering, as well as to introduce many other factors affecting professional and social development.

Professional and Social Development

It is practically impossible under the present system to give in four years a general education and a professional education. Engineering might have to adopt the practice of medicine or law in order to attain the same professional status. Beneficial effects accrue from extra-curricular activities of various kinds. Professional attitudes and ethics might be inculcated as much by example in the daily classroom as by the prepared lecture. Teachers themselves who believe and practice professional standards, attitudes, and ethics teach indirectly through example.

Recommendations

The only recommendations which the committee cares to make in this first report are concerned with creative thinking. These are:

a) More effective use should be made of existing selective tests.
b) Engineering faculties should cooperate with psychologists in developing tests designed to measure abilities required in specific engineering fields.
c) Engineering courses which emphasize transfer of material from the theoretical to the applied should be developed.

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Review of Current Research Available . . .

You can now get your copy of the "Review of Current Research and Directory of Member Institutions," published by the ECRC, which is just off the press. This is a complete directory of research projects in engineering colleges throughout the country. For a copy write to Professor Virgil Neilly at Pennsylvania State College, State College, Pa. The price is $2.50.

American Society for Engineering Education Committee on Atomic Energy Education

Future Activities of the Committee

A Report to the General Council of the Society, June 26, 1953

In the three years during which the ASEE Committee on Atomic Energy Education has been in existence a reasonably definite pattern has emerged which indicates its general fields of activity in the future.

The first important responsibility of this committee is to act as a liaison group between the ASEE and the AEC. Such matters as declassification by AEC of nuclear engineering information, and AEC policies with respect to support of engineering education by such means as engineering fellowships, nuclear engineering facilities at engineering colleges, and development by AEC of teaching aids, are topics for discussion by the committee. The committee is in a position to give the AEC advice as to what policies might be desirably adopted in this field, and to obtain information for the colleges from the AEC as to what is feasible from the standpoint of budget, facilities, etc. Accordingly, it may be assumed that the committee will serve an important role in the future to transmit information back and forth between engineering educators and the AEC.

The committee has at present two active sub-committees. The first of these has been appointed to follow the progress of the "Sourcebook on Nuclear Engineering" and give advice to the authors as to the treatment of the subject matter in this book. The necessity for a "Sourcebook on Nuclear Engineering" was discussed by the committee at its meeting in 1951 and the committee requested the Atomic Energy Commission to prepare such a book. The Commission agreed to do so and enlisted the services of Dr. Samuel Glasstone to undertake the writing, with engineering advice to be obtained from the staff of the Oak Ridge School of Reactor Technology. The Oak Ridge National Laboratory has designated Mr. Neal Lansing to represent ORNL in this activity. A classified text is well under way, and the committee has been called upon in the past to furnish advice as to the level to which the material should be written and the subject matter to be included. The sub-committee will continue to work with the authors in developing an effective classified text for use by AEC installations and later in adapting this text to produce the best possible book based on declassifiable information. It is expected that the work of preparing the declassified text will be completed by the late spring of 1954, and it is hoped that the book will be available for classroom use during the academic year 1954–1955.

Facilities Expensive

The second sub-committee is directing its attention to the problem of facilities for studying nuclear reactors in engineering schools. The expense of such facilities has been a deterrent to their use, and there is some question whether many engineering schools are in a position to afford the outlay for even the smallest nuclear reactor. Accordingly, the sub-committee

will include in its program a study of reactor stimulators and other electronic devices which may be used for study of the behavior of nuclear chain reacting systems. It is expected that the task of this sub-committee will be a continuing one for some years, inasmuch as the field is constantly changing. Interest in nuclear reactors on the part of engineering institutions may be expected to increase markedly as industry is brought into the nuclear energy field and makes demands upon the engineering educators for engineers prepared to work in the field.

The committee feels that much more work needs to be done to bring to engineering educators the significance of the U. S. atomic energy program. A number of regional conferences of the ASEE have been devoted to this problem. Most of these have been on an elementary level, designed to present the basic nuclear energy phenomena to engineering staffs. More of these are needed. For example, there has not yet been a conference of this type in the Midwestern region, but one is being planned for this fall. Educational conferences on a higher level are also necessary since there is, as yet, no real agreement among engineering educators as to how nuclear energy should be adapted to the engineering curriculum, and how much of it should be taught in the graduate and undergraduate engineering courses.

New Trends

Finally, new trends will inevitably develop in the U. S. atomic energy program as a result of the operation of two forces. First, the efforts to reduce the U. S. Government budget will undoubtedly have an impact on the atomic energy program, and may have an adverse effect on the funds which the AEC will have available for education and training. The second factor is that the need for education and training will become increasingly acute as the pressure develops to bring American industry fully into the nuclear energy program. It seems apparent that the Committee on Atomic Energy Education will find itself faced with, as yet, unforeseen problems as a result of these tendencies.

Respectfully submitted,
HENRY H. ARMSBY, *Chairman*

ANNUAL MEETING

June 14-18, 1954

University of Illinois **Urbana, Illinois**

Forecasting Academic Achievement in the College of Engineering

By L. E. DRAKE, *Associate Professor of Engineering*

and

W. F. THOMAS, *Assistant Director of Student Counseling*

University of Wisconsin

In counseling students enrolled in the engineering curriculum it is helpful to identify those students who are likely to have academic difficulty as well as those who should achieve highly. For purposes of such identification the Pre-Engineering Ability Test,* Form ZPA, was administered to the entering freshmen in September 1951 and September 1952. By agreement with Dean M. O. Withey, in order to insure that course grades would be entirely independent of the test scores, the scores were not reported to the College of Engineering until the first semester course grades had been recorded.

Centiles, based upon University of Wisconsin norms, for the 1948 Edition of the American Council on Education Psychological Examination were available for most of the students and the rank in the high school graduating class converted to centiles were available for many of the 1952 group. Only those students who carried 12 credits or more the first semester were included. The index of scholarship was computed by assigning 3 points for each credit of A, 2 points for each credit of B, 1 point for each credit of C, 0 points for each credit of D, and by substracting 1 point for each credit of F. Thus grade point averages could range from 3.0 to -1.0.

Table I shows the grade point averages of the Engineering Students for the first semester as classified into various quarters on the basis of the Pre-Engineering Ability Test and the American Council Psychological Examination.

First quarter refers to the upper 25% based on local norms for the American Council Psychological Examination. Raw scores were used for the Pre-Engineering Ability Test grouped as follows: 1st quartile $52 \rightarrow$; 2nd quartile $43 \rightarrow 51$; 3rd quartile $36 \rightarrow 42$; and 4th quartile $0 \rightarrow 35$. As indicated in Table I, of the 103 students who obtained scores in the first quarter on both tests 50% obtained grade point averages of 2.00 or better, 41% of

TABLE I

GRADE POINT AVERAGES FOR THE 1ST SEMESTER 1951 AND 1952 FRESHMEN ENGINEERS IN RELATION TO THE ACE AND PRE-ENGINEERING ABILITY TESTS

	G. P. A.			
ACE and Pre-Engr.	3.0–2.0	1.9–1.0	.9→	No.
1st Quarter on both	50%	41%	9%	103
1st Q. on 1 & 2nd on other	36%	43%	21%	72
2nd Q. on both	14%	56%	30%	57
2nd Q. on 1 & 3rd on other	10%	54%	35%	68
3rd Q. on both	3%	37%	60%	35
3rd Q. on 1 & 4th on other	2%	36%	62%	56
4th Q. on both	0%	18%	82%	55
			Total	446

*Published by the Educational Testing Service, Princeton, N. J.

1.00 → 1.99, and 9% of less than 1.00 whereas of the 55 students who rated in the lowest quarter on both tests 00% obtained grade point averages of 2.00 or better, 18% between 1.9 → 1.0 and 82% of less than 1.00. Although the Pre-Engineering test alone gives almost as good a separation of students at the top, the use of both tests improves the separation at the lower extreme.

Since some students, for various reasons, may miss taking the American Council Psychological Examination, Table II is presented in which rank in high school graduating class converted to centiles is used instead of American Council Psychological Examination. These data were available only for the 1952 group and hence the number is rather small.

The number should, perhaps, be larger if the table is to be used as an expectancy table, although it was found that separate tables for the 1951 and 1952 groups for the American Council Psychological Examination and the Pre-Engineering Ability Test were practically the same.

TABLE II

GRADE POINT AVERAGES FOR THE FIRST SEMESTER 1952 FRESHMEN ENGINEERS IN RELATION TO HIGH SCHOOL RANK AND THE PRE-ENGINEERING ABILITY TEST

	G. P. A.			
H.S.C.R. and Pre-Engr.	3.0–2.0	1.9–1.0	.9→	No.
1st Quarter on both	50%	42%	8%	66
1st Q. on 1 & 2nd on other	19%	58%	23%	57
2nd Q. on both	4%	36%	60%	25
2nd Q. on 1 & 3rd on other	4%	38%	58%	26
3rd Q. on both	0%	56%	44%	9
3rd Q. on 1 & 4th on other	0%	35%	65%	17
4th Q. on both	0%	17%	83%	6
			Total	206

Conclusion

It appears from these data that the Pre-Engineering Test in conjunction with either the American Council Psychological Examination or centile rank in high school graduating class separated the high achieving students from the poor achieving students very well.

It is recommended that such expectancy tables be used to counsel with students early in their first semester in Engineering or before entering when possible either to assist them to gain an understanding of their needs for more effective methods of learning and application of effort, or to transfer to some subject matter field in which they may have higher capabilities. It is not recommended that such data be used alone for the elimination of students from the study of engineering although it might well be used, along with other data, in making decisions regarding borderline cases for admission to a College of Engineering.

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Present Limitations and Future Possibilities of Accreditation and Its Effect on the Standards of Engineering Education*

By JOSEPH C. OSBORN

Assistant Professor of Civil Engineering, Montana State College

The report † of the Engineers Council for Professional Development, Committee on Adequacy and Standards of Engineering Education indicates that there is a wide variation between engineering schools of the country in the matter of standards. The report furthermore indicates that the committee is of the opinion that such wide variation is not desirable, and steps to remedy the situation are outlined. The Committee, of course, believes that accrediting procedures must continue, but that they are less effective in achieving the improvement of schools than self-appraisal of schools by their own faculties. I agree that improvement *should* be in response to this impulse from within the school rather than in response to prodding from without. However, suppose that the urge to make a critical self-appraisal is lacking? The report states: "Accrediting procedures relate almost entirely to the minimum standards, and tend to breed complacency among those schools that just barely satisfy such a standard." An attitude of complacency is not conducive to self-appraisal, and those who are complacent may even be antagonistic to the idea that all is not as it should be.

Limitations

The limitations of accreditation are fairly obvious, but should be reviewed here:

First: The accrediting procedure is intermittent. An examining committe may have passed judgment on the curricula, staff and equipment of an institution, and found these items acceptable. Shortly thereafter, a large fraction of the staff of a particular department may have departed, and recruits may have taken the vacant places. Such a change could be for the better, or it could be for the worse, or it could be neutral. If an institution is inclined to frown on those teachers who might make alterations in the existing educational pattern, such a change in staff will probably result in a lowering of standards. In general, if a school has a large staff turn-over, the report of the examining committees quickly becomes out-dated.

Second: Though ECPD makes the final appraisal of a curricula of an institution, the examining committee is a regional committee. If regional differences in standards exist, they would tend to be perpetuated by this procedure.

Third: The examining committee can most easily appraise tangible things such as the qualifications of the staff, and caliber of equipment. It is true that the *potential* standards of an institution are determined in this fashion, but the actual standards are governed by what is required of the student. It is quite possible that a highly qualified instructor may be quite lenient. If an institution does not have a long standing tradition of high standards of achievement required of its students, then, over a period of years, the members of the instructional staff will

* Presented at the meeting of the Pacific Northwest Section, ASEE at Washington State College, April 24–25, 1953.

† P. 249 ff., Jan. 1952, Vol. 42, No. 5, *Journal of Engineering Education.*

consciously or unconsciously conform to their environment.

Fourth: Institutions are inclined to put their best foot forward during the brief period of the visit of the examining committee. This is only human, and I presume that the practice will continue.

There are several things which are conducive to low standards which would not be apparent to the examining committee unless their scrutiny were to be considerably extended. As I have previously stated, standards are determined by what is required of the student. In order to determine what is required in a particular course, it is necessary to appraise the examinations which are given *and the way in which the students exam papers are graded.* If a teacher makes heavy use of the class performance on a quiz in determining the grades the students receive, the appraisal of the standards of the course is doubly difficult.

Information is Misleading

The present accrediting procedure includes an examination of the requirements for admission of students to engineering schools, but here again the information is misleading. Different high schools have widely different standards, and students coming from sparsely populated regions are frequently inadequately prepared in mathematics. If the students who are admitted are poorly prepared, and if the teachers consider the class average in formulating grades, and if the administrative officers of a school appraise a teachers effectiveness by his grade distribution—the combination of these things leads automatically to low standards. Any one of these things alone is certainly conducive to low standards.

When the charge is made that the standards of a particular school are too low, the officials of that school are tempted to counter with a recitation of the accomplishments of a few talented and conspicuous graduates. This, of course, is human, but such a recitation had better be reserved for homecoming banquets. It has very little place in evaluating the caliber of a school. Of course, a statistical study of *all* the graduates is highly pertinent in measuring the quality of a school. However, such data is difficult to obtain, and when obtained, gives only a measure of the school a number of years in the past. In making a present appraisal, it is necessary for us to project ourselves a number of years into the future, and to visualize coming professional requirements.

Another thing which is indicative of low standards is a wide spread between the requirements for the highest and lowest passing grades in a particular course. In other words, a student receiving an "A" grade, or whatever the highest grade may be designated, may compare favorably with a student receiving a similar grade at a school whose standards are high, but another student who received a barely passing mark at this hypothetical school with a wide spread between grades, may be considerably below the passing level at a school with high standards. There are two reasons for the existence of this situation. One is habit, and the other is the scarcity of sub-professional schools or technical institutes. A letter from Dr. H. P. Hammond to Dean Thorndike Saville states the situation clearly: ‡ "I think it is significant and important to point out that the number of technical institutes is inversely in proportion to the number of engineering colleges as the need for them exists in this country. Broadly speaking, and with exceptions, they are inadequate also in quality to produce the sub-professional technically trained personnel needed by industry and government. The result is that the engineering colleges are forced to carry a load of what is actually sub-professional training for poorly qualified students who will never become genuine professional engineers. *And many colleges are perfectly willing to do it. This is one of the greatest sources of low stand-*

‡ P. 233, Dec. 1952, Vol. 43, No. 4, *Jour. of Eng. Educ.*

ards of accreditation. It is the reason I advocated the establishment of the subcommittee on technical institutes and this had some benefits, I think, but it has not accomplished what I hoped it might and it never will unless industry, the profession itself, and the colleges get a new conception of engineering as a professional pursuit and of technical institutes as the appropriate source of sub-professional technicians."

Dissimilar Tasks

I am firmly convinced that when engineering schools attempt to perform these two dissimilar tasks—professional and sub-professional training—simultaneously neither job will be done well. Can you imagine a medical school of high repute granting the M.D. degree to poor students who intended to become hospital administrators rather than medical practitioners? I consider it very appropriate for examining committees to scrutinize most carefully the range of knowledge and achievement which a school permits for those students passing a particular course.

Another practice which is inimical to the maintenance of high standards is the practice of permitting students to make substitutions for those courses in their curricula which they have found to be difficult, or which they expect to find difficult. Actually, a student who manages to complete a curriculum in this way is not being graduated from an accredited curriculum, even though there may be nothing on his diploma to indicate that fact.

Conclusion

In conclusion, then, I would like to see the extension of those activities which we have associated with the accrediting process. Perhaps the label "educational counseling" would be a preferable one for the process I have in mind. Possible procedure of operation might be something like this: A national committee for a particular curriculum, mechanical engineering for example, would consist of thirty or forty men who would formulate general policies regarding programs of study in mechanical engineering. This committee would be subdivided into groups of three or four one group of which would visit twelve to fifteen schools in a year, remaining at each school for about two weeks. The process should be repeated every year or at most every second year. The function of this committee would be not only to serve as an accrediting committee, but would be to give direction and unification to engineering education over the entire country. Such a program would be expensive, costing perhaps a half-million dollars a year for a curricula like civil or mechanical engineering. However, this amount distributed to all the schools on the basis of enrollment would not be excessive and I think that the long range benefits to the engineering profession would more than justify the cost.

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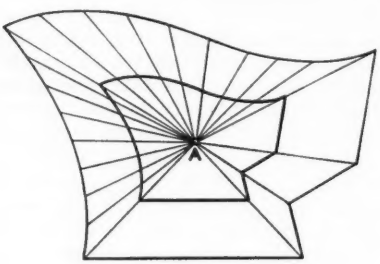
A Construction for Enlarging or Reducing Areas

By ALBERT JORGENSEN

Professor of Mechanical Engineering, University of Pennsylvania

The simple method shown here has many potential uses in the drafting room and shop. For instance, it may be used to enlarge patterns which, for convenience, have been drawn to a reduced scale. Obviously the construction may be used for changing the size of any drawing.



The writer believes the method to be of sufficient importance to warrant its inclusion in basic drawing courses.

In the figure, assume that the heavier lines represent the outline of an area whose dimensions are to be doubled. Point A was chosen at random and through it lines were drawn to significant points on the original outline and then extended an equal distance. The outer ends of these lines determined the outline of the desired area.

Point A may be chosen in any convenient location. Its position affects the location of the resulting enlarged or reduced area.

If it is desired that the two areas do not overlap, it is necessary that point A be located outside the original area.

Section Meetings

Section	*Location of Meeting*	*Dates*	*Chairman of Section*
*Allegheny	University of Pittsburgh		W. I. Short, University of Pittsburgh
Illinois-Indiana	Illinois Institute of Technology	May, 16, 1954	R. G. Owens, Illinois Institute of Technology
Kansas-Nebraska	Kansas State College	Oct. 9–10, 1953	M. H. Barnard, University of Nebraska
Michigan	University of Michigan	May 8, 1954	F. L. Schwartz, University of Michigan
Middle Atlantic	University of Pennsylvania	Dec. 5, 1953	C. Bonilla, Columbia University
Missouri-Arkansas	Missouri School of Mines	April 10, 1954	V. J. Blum, St. Louis University
National Capital Area	Library of Congress	Feb. 2, 1954	C. H. Walther, George Washington University
New England	University of Vermont	Oct. 10, 1953	E. T. Donovan, University of New Hampshire
North Midwest	Marquette University	Oct. 9–10, 1953	A. B. Drought, Marquette University
Ohio	Ohio State University	May 1, 1954	R. S. Paffenbarger, Ohio State University
Pacific Northwest	Oregon State College	April 23–24, 1954	L. Slegel, Oregon State College
Pacific Southwest	San Jose State College	Dec. 29–30, 1953	C. M. Duke, University of California at Los Angeles
*Rocky Mountain	University of Utah		A. Diefendorf, University of Utah
Southeast	North Carolina State College	March 25–27, 1954	J. R. Cudworth, University of Alabama
Southwest	University of Texas	April 16–17, 1954	J. J. Heimerich, University of New Mexico
Upper New York	Rochester Institute of Technology	October 16–17, 1953	F. E. Almstead, State University of New York, Albany

Members of the Society are welcome at all Section Meetings

* **No Date Set.**

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June 14-18, 1954

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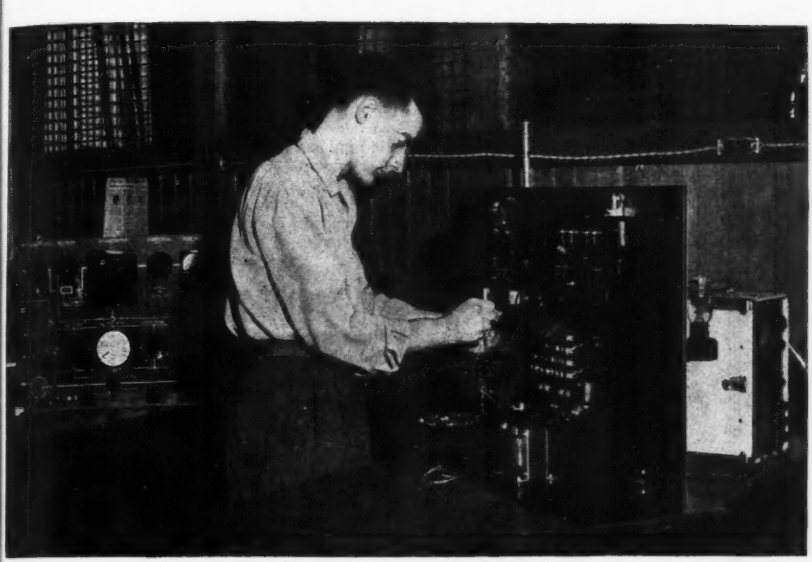

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